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Vol. 9 March, 1926 No. 3

ORIGINAL PAPERS

AN ACCELERATED ABRASION TEST[1]

BY CARL H. GEISTER[2]

ABSTRACT

A suitable abrasion apparatus is described which is capable of measuring the wear resistance of flooring materials having widely varying physical properties. The requisite conditions of wear necessary to produce results comparable to those obtained in actual service are given. Other abrasion methods and their shortcomings for use in this problem are summarized.

Introduction

An abrasion machine was devised to produce accelerated wear during an investigation on floor tile, which is being carried on at Mellon Institute. This machine was designed particularly for testing flooring materials, because no satisfactory method had been previously developed which was adaptable to producing wear in all types of floor coverings in accordance with the required conditions.

Requisite Factors of Wear

Abrasion of floors in service is mainly attributed to foot traffic. The average pedestrian, in the course of taking a step, strikes the floor with his heel, causing a definite impact shock. Slipping results when he shifts his weight to the sole and twists the foot in continuing

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb., 1926. (White Wares Division.) Recd. Dec. 6, 1925.

[2] Industrial Fellow, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

the step. The wear is produced by straight and twisting slippage of leather or rubber over floor surfaces in conjunction with grit.

The essential factors involved in working out a satisfactory abrasion test are as follows: (1) the conditions of wear must be similar to those in service; (2) leather or rubber must be used as a rubbing medium; (3) the abrasive grit must be loose and clean; (4) both the rubbing material and sample must be constantly cleaned to avoid contamination; (5) the degree of slippage must not be excessive; (6) the pressure exerted on the material must be similar to that applied to floors in service; (7) impact shocks must not be excessive or produced through other materials than those commonly used in shoes; (8) excessive heat must be avoided, and (9) the samples must be kept dry.

Other Abrasion Methods

It is pertinent to describe briefly some of the abrasion methods used by other investigators and point out their shortcomings for this particular research, wherein materials of widely varying physical properties were to be tested.

1. Sand Blast and Falling Abrasives — The wear produced by the use of sand blasts and falling abrasives is caused entirely by impact forces.

2. Fixed Sample Whirled in Loose Abrasives — The ratio of speed to the pressure exerted, when using the method of whirling a fixed sample in a bath of loose abrasive material, is not in the same proportion as that governing the wear in service; greatly increased temperatures are also evident.

3. Rattler Test — The rattler test produces wear mainly by impact forces. The variation in densities of materials causes different wearing effects.

4. Fixed Abrasive Wheel — The use of a fixed abrasive wheel to produce constant wear is a failure because the cutting edges change and the interstices between the abrasive particles fill with the worn material.

5. Rubbing against Hard Materials with Loose Abrasive — The use of rubbing mediums which are harder than the leather or rubber used in service produces an excessive cutting action; therefore, the resultant wear is not comparable to that observed practically.

The methods mentioned fail when materials tested have different characteristics. It is probable that those abrasion methods which can be controlled are acceptable when testing materials having the same physical properties.

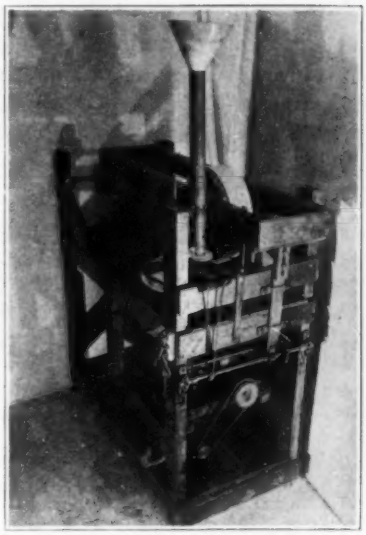

FIG. 1.—Abrasion machine used at Mellon Institute.

Apparatus and Method Used

The apparatus shown in Figs. 1 and 2 was constructed to produce wear in compliance with the requisite factors as previously outlined. The wear is produced by an upright leather wheel rolling on a path of test samples placed on a horizontal revolving disk. Both wheels are driven in the same direction, but at slightly different speeds, by a positive-drive mechanism from a single power unit causing a constant slippage. A line perpendicular to the upright wheel from the point of contact lies two inches from the center of the horizontal disk. This arrangement produces a resultant outward motion, which also serves to constantly clean the samples and leather. The upright wheel is built of leather sections set on edge about its periphery. The best grade of oak tanned sole leather is used. The leather can be replaced without changing the wearing effect.

Two hundred grams per hour of a 60- to 80-mesh, crushed quartz sand is fed on the inside path of the samples by means of a special apparatus, which has a vertical reservoir cylinder placed on a horizontal revolving disk. The constant feeding depends on the flow of the sand through the adjusted opening between the cylinder and disk.

The lifting device is arranged to release the pressure at intervals in such a way that the effect progresses about the path of samples. The lift is adjusted every two hours to raise one-eighth inch above the samples. The test is terminated when the leather wheel has made 20,000 revolutions. The leather wheel is dressed to a true surface before each test, and is rebuilt whenever it has become worn so that its diameter is one inch less than originally.

Three-inch square samples of homogeneous floor coverings are prepared. Pliable materials are cemented securely to rigid aluminum

plates. The triangular separating segments are of the same materials as the samples following them. Groups of tiles, cements, marbles, oxychloride cements, asphalts, woods, rubbers, and linoleums are tested each time. The samples, which are approximately one-half inch thick, are placed in the groove of the horizontal disk so that their exposed surfaces are of equal height. The weight or thickness losses

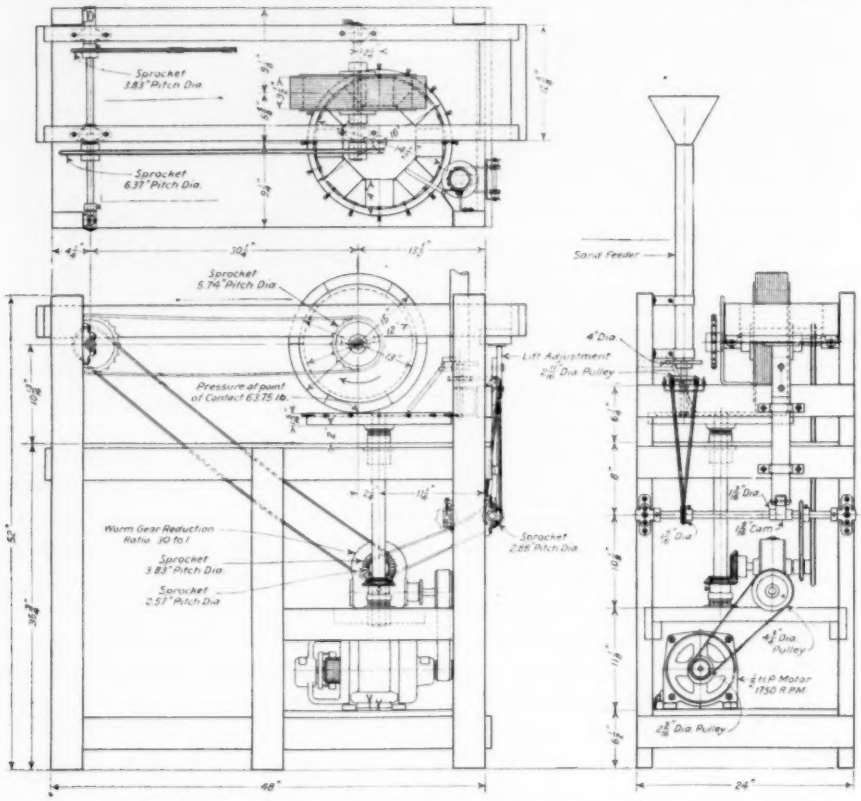

FIG. 2.—Details of construction of abrasion machine used at Mellon Institute.

of the flooring materials are noted and calculated to the percentage basis. Consideration has not been given to testing the resistance to abrasion of paint films or of surface dressings.

Accuracy of Test Method

The results obtained in a series of tests on individual trade materials of different types are given in Table I.

TABLE I

VARIATION OF RESULTS FROM TESTS ON DIFFERENT MATERIALS

Material	Test 1 Per cent loss average 2 samples	Test 2 Per cent loss average 2 samples	Test 3 Per cent loss average 2 samples	Test 4 Per cent loss average 2 samples	Average Per cent loss	Maximum Per cent variation from average
Vitreous tile	4.65	4.39	4.69	4.56	4.57	3.93
Marble	22.88	23.23	23.49	22.73	23.18	1.94
Maple wood	24.18	24.33	23.27	23.39	23.79	2.27
Rubber	20.64	19.34	22.28	20.09	20.59	8.21
Linoleum	54.47	56.12	61.07	54.64	56.57	7.95
Oxychloride cement	53.17	49.03	50.92	47.30	50.10	6.12
Neat Portland cement	17.95	15.31	18.83	15.07	16.79	10.24
Asphaltic composition	78.05	88.01	80.63	73.76	80.11	9.86
Cork tile	46.02	44.86	42.63	50.20	45.93	9.29

The accuracy of the method is acceptable in view of the possible varying of materials and the accelerated wear. The factors governing the abrasion are similar to those in service. The results are logical and compare favorably with those generally expected of materials in service.

ENDURANCE OF FLOORING MATERIALS[1]

By Carl H. Geister[2]

ABSTRACT

The findings of a practical investigation of flooring materials are summarized. The endurance and sanitary properties of the materials were determined by use of the abrasion, absorption, indentation, chemical, stain, and age tests. The methods used are described.

Introduction

The endurant and sanitary properties of floor tile and of other floor coverings are being investigated at Mellon Institute. These qualities, which are considered of major importance in ascertaining the serviceability of flooring materials, are evaluated by determining the resistance of the materials to abrasion, absorption, indentation, chemicals, stains and deterioration from age. The test methods used as well as the results obtained thus far will be summarized in this paper. The requisite properties of floor materials and the practical conditions under which they are impaired have been discussed in several papers presented by the writer before the American Hospital Association.[3]

Methods of Test

For the purpose of determining the physical properties of materials in this investigation, in the light of the requirements of the study, it has been necessary to standardize certain test methods which will be of interest and applicable in problems of similar nature.

1. Abrasion An abrasion machine was built which was designed so that it is capable of closely imitating the wear produced on floors in service. Straight and twisting slippages as well as a stepping effect are produced. Pressure equal to that caused by the average person is applied to the sample by a leather rubbing surface, which in conjunction with siliceous grit affects the wear. The wear is produced without excessive temperatures or contamination of the leather and flooring material. A detailed description of the machine and method is given in the writer's paper, "An Accelerated Abrasion Test."[4]

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb. 1926. (White Wares Division). Recd. Dec. 6, 1925.

[2] Industrial Fellow, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[3] "Adaptability of Tile to Hospital Requirements," presented before the American Hospital Association, Buffalo, N. Y., October 9, 1924; published in *Modern Hospital*, **23** [6], 575 (1924), and in *Hospital Buyer*, **3** [1], 16 (1924).
"Condition of Floors after Continued Service," presented before the American Hospital Association, Louisville, Ky., October 22, 1925.

[4] See preceding paper, *This Jour.*

2. Absorption A method, which is in accordance with that prescribed in the Navy Department's specifications (29 L1C of September 1, 1916), was used in measuring the porosity of floor coverings. Only the homogeneous parts of the materials are considered, since surface dressings are not consistently used or are worn off shortly after application, and the various backings are not directly subjected to absorption.

The sublayers of cement, burlap or felt are removed. Samples weighing approximately fifty grams are prepared, which are dried and weighed. They are placed in water, kept at a temperature of 70°F, and removed for weighing when 24-, 48-, and 120-hour periods have elapsed. The adhering surface moisture is carefully blotted or wiped off, a period of two minutes being allowed for the blotting and weighing operations. The percentage increases are calculated from the following formula:

$$\frac{\text{Weight increase}}{\text{Original weight}} \times 100 = \text{percentage increase.}$$

3. Indentation An apparatus was constructed in which a definite load can be applied to the caster that is fastened to a vertical shaft and rests on the sample. Tests were made in which loads varying from seventy-five to one hundred pounds were applied to casters ranging from one to three inches in diameter. The duration of the test was also varied. The effects caused by casters having steel, wood, felt or rubber wheels were studied. It was found that results obtained by the use of a one-inch steel caster under a load of seventy-five pounds for forty-eight hours are applicable in measuring resistances to depressions or pits caused by concentrated loads. The depressions after seven days' rest are of a permanent character. The percentage depths of depressions are calculated from the formula:

$$\frac{\text{Depth depression}}{\text{Original thickness}} \times 100 = \text{percentage depth depression.}$$

4. Chemicals Only the homogeneous parts of materials are considered, as in the absorption test. The resistances of the materials to the following chemicals are determined:

	Per cent		Per cent
(*a*)	10 sodium bicarbonate	(*g*)	10 oxalic acid
(*b*)	5 phenol	(*h*)	50 sodium hydroxide
(*c*)	35 nitric acid	(*i*)	5 tincture of iodine
(*d*)	35 hydrochloric acid	(*j*)	5 potassium permanganate
(*e*)	50 sulphuric acid	(*k*)	4 sodium hypochlorite
(*f*)	15 acetic acid		

Samples weighing approximately ten grams are prepared, dried and weighed. They are submerged in the chemicals for twenty-four hours,

removed and washed thoroughly or until the supernatant liquor does not show presence of the chemical after standing six hours. The samples are dried and weighed, and the percentage weight losses calculated.

After noting the visible physical changes, deterioration values are estimated. The changes in hardness are measured by means of the durometer apparatus. The physical changes and percentage losses are combined equally to determine the total deterioration values.

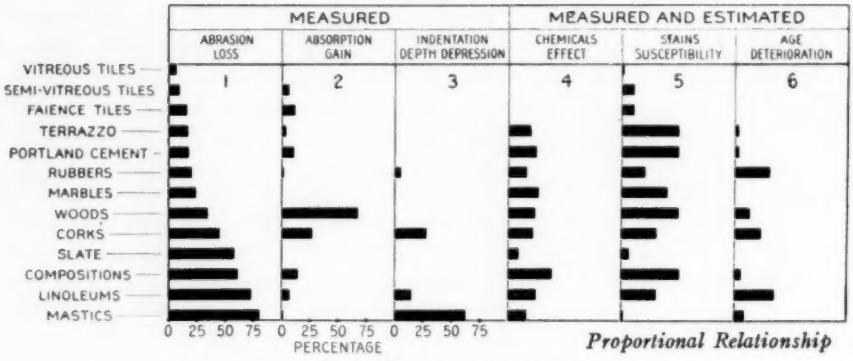

FIG. 1.—Summary of tests on flooring materials.

1. Per cent losses resulting from 20,000 revolutions of the leather wheel.
2. Per cent weight increases resulting from five days in water.
3. Per cent depth depressions after forty-eight hours under a one-inch caster, bearing a load of 75 pounds.
4. Composite values of per cent weight losses and estimated physical changes when treated with sulphuric, nitric, hydrochloric, carbolic, acetic and oxalic acids, and sodium hydroxide, sodium carbonate, iodine and potassium permanganate.
5. Composite values based on depths of penetration and degree of staining when treated with eosin, methylene blue, iodine and potassium permanganate.
6. Composite values of deteriorations resulting from water, warmth, sunlight, and alkaline soap powders.

5. Stains Samples measuring approximately 1 x 2 inches are prepared, dried and placed in 5% solutions of methylene blue, eosin, iodine and potassium permanganate. The samples are removed and rinsed after twenty-four hours have elapsed. The depths of penetration are measured, and consideration is also given to the degree of surface stains, physical changes, removal of stains, and resistance of the materials to chemical reagents. These five considerations are combined equally in determining the susceptibility of materials to stains.

6. Age The resistance of materials to deterioration from age caused by moisture, heat, sunlight and alkaline soap powder is found. The materials are soaked in water for four months; their weight losses

TABLE I

SUMMARY OF RESULTS FROM TESTING A REPRESENTATIVE NUMBER OF EACH MATERIAL

Type of Material	Thickness of Samples, Inches[1]	Abrasion Test, Per cent Loss 20,000 Revolutions	Absorption Test, Per cent Gain 5 Days	Indentation Test, Per cent Depth Depression[2]	Chemicals, Effect of, Measured and Estimated [3]	Stains, Susceptibility Measured and Estimated [4]	Age Deterioration Measured and Estimated [5]
Vitreous tiles	½	4.5	0.0	0.0	0.0-*A*	*A*	*AAAA*
Semi-vitreous tiles	½	8.6	5.1	0.0	0.0-*A*	*B*	*AAAA*
Faience tiles	½	15.3	10.6	0.0	0.0-*A*	*B*	*AAAA*
Terrazzo	½	16.1	2.6	0.0	11.4-*D*	*F*	*AAAB*
Portland cement	½	16.8	9.6	0.0	16.7-*D*	*F*	*AAAB*
Rubbers	¼	19.8	1.1	4.0	10.5-*C*	*C*	*EDBE*
Marbles	⅞	23.3	0.1	0.0	22.2-*D*	*E*	*AAAA*
Woods	½	33.8	66.1	0.0	15.2-*D*	*F*	*AACD*
Corks	½	44.2	25.5	26.7	12.4-*D*	*D*	*BAEE*
Slate	⅞	58.2	0.3	0.0	6.0-*B*	*AB*	*AAAA*
Oxychloride cements	½	60.4	13.1	0.0	34.5-*E*	*F*	*AABB*
Linoleums	⅛ and ¼	72.9	6.2	13.6	16.5-*D*	*D*	*EBEF*
Asphaltic compositions	¼ and ½	80.1	0.8	61.9	21.0-*B*	*A*	*CAAB*

[1] All samples were 3 inches square.

[2] Percentage depth depressions caused by a 1 inch caster under a load of 75 pounds for 48 hours.

[3] Percentage weight losses and estimated physical changes.
The letter *A* represents the minimum change.

[4] Combined values of depths of penetration, estimated degree of surface stains, and observed ease of removal.
The letter *A* represents the minimum susceptibility to stains.

[5] Deterioration values based on weight losses, hardening, rotting, fading, blistering, checking and swelling caused respectively by warmth, sunlight, moisture and alkaline soap powders. The letter *A* represents minimum deterioration.

and hardness changes are measured; the tendencies to fade, swell or decay are noted.

Samples are placed in an oven and kept at a temperature of 60°C for three months. The weight and hardness changes are measured, and the visible physical changes, as blistering and cracking, noted. Consideration is also given to the resulting odors.

The materials are subjected to sunlight for four months. They are protected from moisture by glass, which does not wholly remove the damaging effect of the sun. The hardness and physical changes, such as checking and fading, are observed.

The materials are placed in a 10% (by weight) soap powder solution which is kept at a temperature of 60°C. The weight losses and hardness changes are measured, and the degree of swelling, fading and decaying of materials estimated. The resistances of materials to moisture, heat, sunlight and alkaline soap powders are considered.

Experimental Results

The physical properties studied are presented concisely in Fig. 1, which is based on the results given in Table I.

Conclusions

The methods discussed are applicable for determining practically the behavior of flooring materials in service with special attention to their durability and hygienic aspects. It has been shown that tiles have maximum endurant properties and greatly assist in producing sanitary conditions. Tiles are fireproof, which quality is endorsed by their general use in fireplace construction. They are inodorous, resistant to abrasion, moisture, chemicals and stains, and do not deteriorate with age.

PROGRESS REPORT ON INVESTIGATION OF SAGGER CLAYS[1]

By R. A. Heindl

ABSTRACT

This paper is the first progress report of a comprehensive study of sagger clays. It includes the results of a preliminary study of clays representative of those used in sagger making throughout the United States. Chemical analyses, and a summary of physical tests, petrographic examinations, and the effect of repeated burns in pottery kilns are given. As a result of this work the clays have been classified into five groups characterized by properties in the fired state. The paper also contains an outline of a proposed intensive and fundamental study of a limited number of clays typical of each group.

Introduction

The uses and limitations of saggers, their shapes and sizes, the methods of their manufacture, and the raw materials used, have been discussed at great length in ceramic literature.[2] While much of the information contained in the articles referred to is elementary, the specific data are usually based on results of long and painstaking investigations. This is no doubt enabling the potter to produce better saggers, but the breakage is still high and causing a loss of millions of dollars annually.[3] To assist the industry in eliminating this waste, the Bureau of Standards, in coöperation with the United States Potters Association, undertook a comprehensive investigation of sagger clays. While it is the ultimate purpose of this work to obtain a better understanding of all the factors controlling the life of saggers, the first phase of the investigation is being confined to a study of the characteristics of the individual clays.

Scope

Samples of fifty-one different clays, representing as well as could be judged, all the important clay mining districts of the country, were included in the investigation. Four-hundred pound samples of each clay were obtained from the consumer whenever possible, rather than from the producer, in order that experimental results might represent the properties of clays as actually used in the plant.

In order to classify the sagger clays according to their properties, the following determinations were made: (1) water of plasticity; (2) volume and linear shrinkage; (3) porosity and modulus of rupture

[1] Published by permission of the Director of the Bureau of Standards of the U.S Department of Commerce. Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (White Wares Division.) Received December, 1925.

[2] *Transactions* and *Journals of the American Ceramic Society*. "Clays, Occurrence, Properties and Uses," by H. Ries. "The Chemistry and Physics of Clays and Other Ceramic Materials" (1924), and "Refractory Materials, Their Manufacture and Uses," 2d Ed. (1924), p. 442 by A. B. Searle.

[3] *Bull. Amer. Ceram. Soc.*, 1 [3], 103 (1923).

in the dry state; (4) softening point; (5) strength, porosity and shrinkage after firing at five different temperatures; (6) resistance to dunting; (7) petrographic examination and chemical analyses.

Methods of Testing and Results

Unfired Clays Saggers used in industrial practice contain a large percentage of variously sized grog. To simulate this condition and to facilitate proper drying of the bodies, test bars 1x1x7 inches were made consisting of 50% clay and 50% of sized grog. The grog used was made in each case from the clay with which it was to be bonded, thereby eliminating any factors which might influence the properties of the individual clay due to admixed clay, or clays. In preparing the grog, the clay was well pugged, fired at 1200°C for one and one-half hours,[1] cooled, crushed and screened. Thirty per cent of the grog used in all test specimens passed a No. 20 and was retained on a No. 40-sieve, and 70% passed a No. 40-sieve.

Water of Plasticity The water of plasticity was determined according to the standard AMERICAN CERAMIC SOCIETY method except that the results were calculated as a percentage of the plastic instead of the dry weight. The water of plasticity ranged from 13.7 to 31.7%, with an average of 19.5%; 92% of the clays had sufficiently good working qualities so that they could be used satisfactorily for the purpose intended.

Volume Drying Shrinkage The volume drying shrinkage was determined according to the standard AMERICAN CERAMIC SOCIETY method for shrinkage water except that the results were calculated as a percentage of the plastic rather than the dry volume. The shrinkage ranged from 9.1 to 16.9%, with an average of 13.1%.

Linear Drying Shrinkage The linear drying shrinkage was measured on the briquets which were prepared for the fired-strength tests. The lowest linear drying shrinkage was 2.8%, the highest 6.1%, and the average 4.5%.

Porosity The porosity was calculated in accordance with the following formula:

$$P = \frac{S - D}{Vd} \cdot 100$$

P = percentage porosity
D = weight of test piece after having been dried at 110°C to constant weight
S = weight of test piece saturated with kerosene
V = volume of dry test piece
d = density of kerosene

[1] This heat treatment was used in order to produce a grog which was sufficiently fired to have the requisite mechanical strength and still porous enough to bond well with the raw clay.

The volume of the dried briquet which had been used for the water-of-plasticity test, was determined as follows: The clay specimen was completely immersed in kerosene for two and one-half hours at an absolute pressure of four millimeters of mercury. The saturated test piece was then taken from the bath, wiped lightly with a cloth to remove excess kerosene, and weighed in air to the nearest 0.1 gram. The weight of the briquet suspended in kerosene was also determined. The difference between these two weights divided by the density of the kerosene gave the volume of the specimen. The average of determinations on three specimen bars 1x1x2 inches was considered representative. The porosity ranged from 24.4 to 50% and the average was 31.9%.

Modulus of Rupture

For the determination of dry modulus of rupture, clay bars 1x1x7 inches were dried for ten days at room temperature, 24 hours at 50°C, and finally 24 hours at 110°C. The linear measurements were made to the nearest $\frac{1}{1000}$ inch.

The moduli of rupture varied from 46 pounds per square inch for the slightly plastic clays to 386 pounds per square inch for a clay of superior plasticity. The average modulus of rupture was 221 pounds per square inch. All of the clays which had relatively poor plasticity showed a modulus of rupture of less than 100 pounds per square inch, while over 75% of the remaining clays showed a modulus of rupture of 200 or more pounds per square inch. No close relation appears to exist between porosity and modulus of rupture, although in those samples showing relatively little plasticity the porosity is generally high.

Softening Point

The softening points were determined in an electrically heated muffle,[1] by comparison with Orton pyrometric cones. The heating schedule followed is approximately that prescribed in the A.S.T.M. Standard Method of Test for Softening Point, Serial Designation C 24–20.

The lowest softening point was found to be cone 14+; in general the determinations indicate that the majority of the clays are of good refractory quality.

According to softening points, the 51 clays may be classified into four groups, as follows:

Group 1 Sixteen clays having a softening point equivalent to or above that of cone 31.

Group 2 Nineteen clays having a softening point ranging from cones 28 to 30 inclusive.

Group 3 Twelve clays having a softening point ranging from cones 20 to 27 inclusive.

Group 4 Four clays having a softening point equal to or below cone 19.

[1] W. L. Pendergast, "Electric Furnace for Softening Point Determinations," *Jour. Amer. Ceram. Soc.*, **8** [5], 319 (1925).

Chemical Composition The chemical analyses of the unfired clays (Table I) consisted of the routine determination of ignition loss, SiO_2, Al_2O_3, Fe_2O_3 and TiO_2. Other constituents were not determined, but the difference between 100% and the sum of the percentages of ignition loss, SiO_2 and Al_2O_3 was regarded as the

TABLE I

CHEMICAL COMPOSITION OF SAGGER CLAYS

Clay	Loss on ignition	SiO_2	Fe_2O_3	TiO_2	Al_2O_3	Other flux (by difference)
1	8.5	63.6	1.5	1.3	21.9	3.2
2	9.8	61.4	1.6	1.6	24.8	0.8
3	6.0	73.4	1.3	1.3	17.0	1.0
4	11.3	50.5	3.8	1.2	31.3	1.9
5	9.9	58.3	1.2	1.1	27.9	1.7
6	14.8	43.7	0.9	1.7	38.7	0.2
7	11.8	51.4	3.0	1.2	30.8	1.8
8	10.9	52.6	3.9	1.2	29.8	1.6
9	12.9	46.8	0.9	2.0	35.9	1.5
10	8.5	65.3	1.1	1.3	23.1	0.7
11	14.5	42.9	1.8	2.5	37.9	0.4
12	10.7	54.7	1.3	1.6	29.8	1.9
13	10.7	66.1	0.6	1.2	20.0	1.4
14	13.9	51.8	1.0	1.6	29.5	2.2
15	7.3	64.1	1.5	1.1	22.7	3.3
16	14.1	42.4	0.5	1.3	39.5	2.2
17	12.3	50.4	3.4	1.0	31.4	1.5
18	9.5	56.8	0.9	1.1	30.0	1.7
19	7.6	66.1	0.5	0.8	24.9	0.1
20	8.4	66.1	1.2	1.0	23.2	1.0
21	8.3	60.9	2.0	1.1	26.5	1.2
22	11.1	58.1	0.7	1.0	27.0	2.1
23	6.8	68.5	1.0	1.4	19.3	3.0
24	10.6	56.4	0.6	1.3	29.9	1.2
25	14.0	47.1	0.5	2.5	35.0	0.9
26	8.2	63.8	1.0	1.1	23.1	2.8
27	12.6	57.3	1.5	2.1	25.5	1.0
28	9.8	57.5	2.1	1.6	26.2	2.8
29	8.9	64.9	1.7	1.5	21.3	1.7
30	11.1	55.5	1.9	2.0	28.7	0.8
31	12.7	48.9	1.0	1.7	30.9	4.8
32	8.4	60.6	2.1	1.0	24.3	3.6
33	11.6	53.6	0.9	2.2	30.9	0.8
34	8.1	62.6	0.9	1.5	25.0	1.9
35	8.0	61.6	1.5	1.6	23.5	3.8
36	7.7	56.8	1.8	1.5	26.5	5.7
37	7.0	58.1	3.0	1.0	25.8	5.1
38	7.7	62.1	1.7	1.6	23.3	3.6
39	11.6	54.9	1.3	1.6	28.0	2.6

TABLE I (*concluded*)

CHEMICAL COMPOSITION OF SAGGER CLAYS

Clay	Loss on ignition	SiO_2	Fe_2O_3	TiO_2	Al_2O_3	Other flux (by difference)
40	8.5	62.8	1.0	1.9	24.1	1.7
41	11.7	57.8	0.8	2.0	26.5	1.2
42	8.2	64.6	1.6	1.5	22.4	1.7
43	11.4	52.4	2.5	1.3	29.9	2.5
44	11.7	51.3	1.9	1.2	31.4	2.5
45	8.9	61.3	1.1	1.5	26.2	1.0
46	10.4	59.5	1.2	1.7	25.7	1.5
47	13.4	55.4	3.6	1.3	23.5	2.8
48	10.2	58.5	1.2	1.6	26.5	2.0
49	15.0	49.0	1.5	1.7	32.0	0.8
50	10.9	54.8	1.1	1.8	30.5	0.9
51	10.5	60.2	1.5	1.0	23.7	3.1

percentage of flux. The clays show a wide variation in composition, as indicated by the range in SiO_2 from 49 to 78%, Al_2O_3 from 18 to 46%, and the total flux from 1.5 to 10%.

Rational Composition vs. Softening Point

The rational composition[1] calculated from the chemical analyses, shows that the clay content varies from 43 to 95%, the uncombined quartz from 4 to 53% (except for three clays which show a small excess of Al_2O_3), and the total flux from 1 to 9%. Only four of the clays have uncombined quartz in excess of 40%, 15 clays have uncombined quartz in amounts ranging from 30 to 40%, for 15 clays it varies between 20 to 29%, and the balance have less than 20%.

It is interesting to note that the softening point varies inversely as the ratio of average flux content to the clay content in each of the four groups into which the clays have been classified according to softening point (Table II).

TABLE II

Grouped according to softening points (in cones)	*a* Average clay content	*b* Average flux content	Ratio $\frac{b}{a}$
31 or higher	92.0	4.5	.049
28–31, inc.	75.7	4.6	.061
20–27, inc.	63.9	5.0	.078
Below 19	66.7	6.7	.100

Fired Clays

Ten bars 1 x 1 x 7 inches, made of a composition of each clay and grog as described under testing of unfired clays, were subjected to each of five firings ranging in temperature from 1150°C to 1310°C (cones 3 to 12) with an interval of 40° between

[1] U.S. Bur. Stand., *Tech. Paper*, 279, p. 126.

succeeding firings. (Exceptions: the firing scheduled to be made at 1190°C was made at 1180°C and three clays, the softening points of which proved to be around cone 15 and which consequently overfired at 1270°C, were fired at 1110°C as the minimum temperature instead of 1150°C). The maximum temperature was held in each firing for one

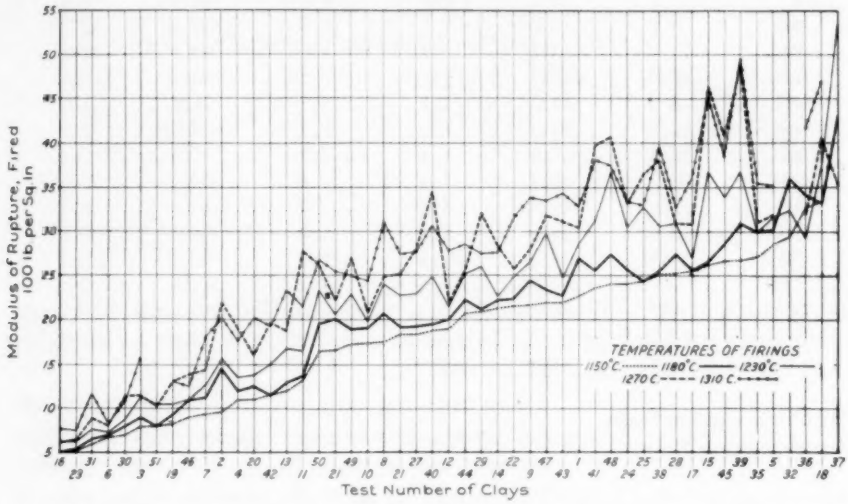

FIG. 1.—Shows that 15 clays had reached their highest transverse strength during the 1270°C firing, and 33 clays showed greater strength after being fired at 1310°C although the porosity and volume shrinkage indicate the latter to be overfired at this temperature (Fig. 2).

and one-half hours to insure equilibrium in the clay for that temperature.

Modulus of Rupture

The results of tests for modulus of rupture are shown in Fig. 1 and summarized in Table III.

TABLE III

RANGE IN MODULUS OF RUPTURE (LBS./IN.²)

Firing °C	Min.	Max.	Av.
1110	405	3850	2600*
1150	500	4340	1880
1180	510	4340	2030
1230	620	5350	2320
1270	610	4850	2590
1310	755	4960	2760

* Average on three clays only.

Figure 1 shows that 15 clays had reached their highest transverse strength during the 1270°C firing, and 33 clays showed greater strength after being fired at 1310°C although the porosity and volume shrinkage indicate the latter to be overfired at this temperature (Fig. 2).

Porosity and Volume Shrinkage

The results of the porosity and volume shrinkage determinations are shown in Fig. 2 and summarized in Table IV.

TABLE IV

RANGE IN POROSITY AND VOLUME SHRINKAGE (PER CENT)

	Porosity			Volume Shrinkage		
Firing °C	Min.	Max.	Av.	Min.	Max.	Av.
1110	18.0	23.5	19.9	2.2	14.9	10.0
1150	17.4	46.5	31.1	1.9	16.3	7.6
1180	13.9	45.9	30.8	2.7	18.2	8.3
1230	8.1	40.8	27.1	4.0	24.7	11.0
1270	1.0	38.5	22.5	2.1	35.7	14.3
1310	8.8	39.2	25.0	2.5	30.2	11.0

The greatest change in porosity in all the clays (clay 15) was from 27.5 to 3.4%; the smallest change (clay 3) was from 33.5 to 31.2%. The greatest change in volume shrinkage (clay 8) was from 7.9 to 26.3%;

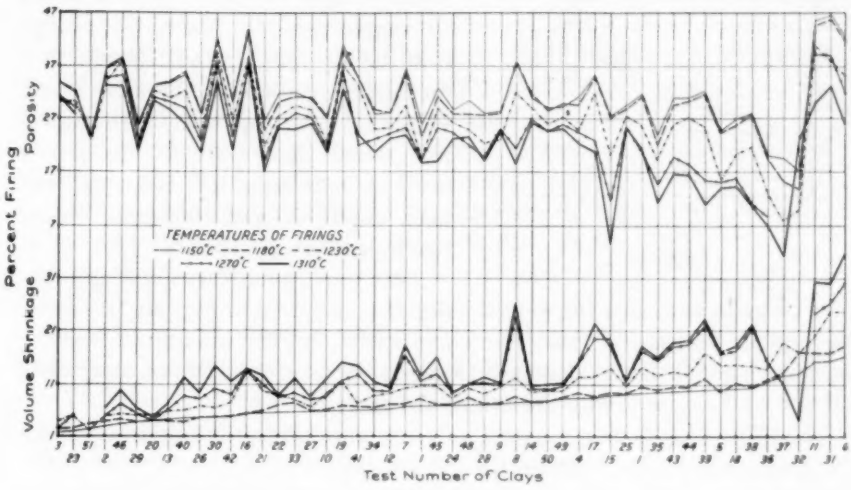

FIG. 2.

and the smallest change (clay 20) was from 4.1 to 5.3%. The curves (Figs. 2 and 3) representing the results obtained by firing the clays at 1310°C, the highest temperature used, clearly show that all clays were overfired.

Petrographic Examinations

Fifteen clays, fired to the five temperatures mentioned above, were examined petrographically. It was noted that the formation of glass and the crystallization of mullite increased with increasing temperatures, and that the presence of glass (due to fluxing impurities) facilitated the growth of mullite

crystals. However, it is now a matter of fairly common knowledge that these reactions take place in all clays when subjected to high temperatures.

Air Quenching or Dunting Tests

Small, oval saggers, 4x4x6x½ inches, were made for the quenching test, in order to simulate the strains developed in commercial saggers. No attempt was made to build an ideal sagger, the object being to obtain a relation between the ability to withstand thermal shock and the nature of the clay. Ten specimen saggers of each clay, made of a composition of 50% grog and 50% clay as described in preceding tests and fired to 1240°C (cones 8½ to 9½), were subjected to the following quenching tests:

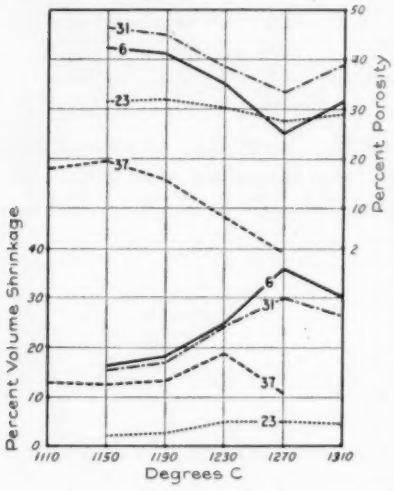

FIG. 3.

(*A*) Five saggers of each clay, at room temperature, were placed in a furnace held at 575°C and allowed to remain there for one-half hour before being quickly withdrawn and permitted to stand in the air. These saggers were subjected to this thermal shock test until fractured, or until a maximum of 30 tests had been made if not fractured before reaching that number.

This experiment was not productive of good comparative results since the majority of saggers fractured during the first test. Only five clays withstood the maximum number of shocks and a sixth, although showing no fracture, did not ring when struck and undoubtedly contained invisible cracks.

(*B*) The second five saggers of each clay were air-quenched from progressively higher temperatures until fracture occurred. The initial furnace temperature was 350°C, the second 400°C, and each succeeding temperature was increased 25°C until 800°C was reached. The test conducted in this manner gave a satisfactory series of comparative results, although the majority of saggers fractured below or at 575°C. Saggers made of one clay, which is undoubtedly a bauxitic clay[1] were still apparently perfect at 1000°C.

In view of the discoveries of Peters,[2] Norton[3] and Booze[4] it is not surprising that no definite relation was found to exist between the

[1] Approximate composition; Al_2O_3 40%, SiO_2 42%, flux 3%, ignition loss 15%.
[2] M. F. Peters, *Jour. Amer. Ceram. Soc.*, **5**, 181 (1922).
[3] F. H. Norton, *Jour. Amer. Ceram. Soc.*, **8** [1], 29 (1925).
[4] M. C. Booze and S. M. Phelps, *Jour. Amer. Ceram. Soc.*, **8** [6], 361 (1925).

relative resistance to failure in the thermal shock test with the physical characteristics of the raw and fired clays or with their chemical composition. Norton and Booze have demonstrated that flexibility in shear, diffusivity, and coefficient of expansion are factors which should be considered in studying the life of refractories in service. Furthermore, Endell[1] has obtained data indicating that variations in expansivity, or thermal dilatation, may be brought about not only by varying the percentages of quartz, and its allotropic forms, but also by varying the fineness of grain. That is, quartz added as coarse crushed ganister may produce a change in expansion entirely different than that caused by an equal quantity present as an exceedingly fine-grained and inherent component of the clay.

A sagger body should be of a good plastic consistency and the sagger in the unfired state must possess reasonable strength and satisfactory drying properties. Therefore, determinations of the water of plasticity, drying shrinkage, porosity and dry modulus of rupture are valuable. Fired saggers must have high mechanical strength to withstand the stresses and shocks incident to handling, and the loads imposed in use; they should have as high a porosity as possible, consistent with strength and thermal diffusivity, in order to withstand thermal shocks; and they should have a relatively low shrinkage in the initial firing to minimize strains and cracks before their full strength is attained. Therefore, determinations of the shrinkage, porosity and strength of the fired clays are valuable. Nevertheless, as is evident from a consideration of the results obtained by these investigators, a satisfactory understanding of the factors controlling the life of saggers in service necessitates a more profound study than the carrying out of such conventional tests as have been described above.

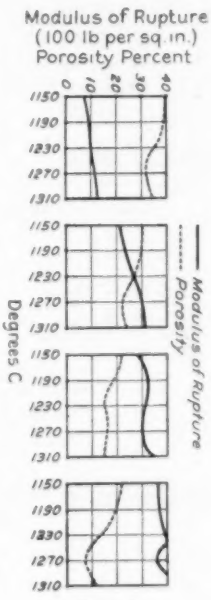

FIG. 4.

In addition to determinations of expansivity, diffusivity, and elasticity, it would also be desirable to study the effect of varying the firing treatment and sizing of the grog. Such an intensive study of each of the 51 clays under consideration, or of even a very small number of the possible combinations of these clays, would be impracticable. Therefore, it was essential to classify or group the clays in order that two or three from each group might be chosen for further study and be logically considered as typical of all the rest.

[1] Berichte der Fachauschüsse des Vereins deutscher Eisenhüttenleute (No. 52) October 10, 1924.

Grouping of Clays

As the highest temperature at which saggers are used is far below the softening point of the average sagger clay, it is obvious that other properties such as strength, porosity or resistance to fracture due to thermal shock are of greater importance than its ultimate refractoriness. It is for this reason that the clays were grouped in the order of increasing average modulus of rupture and decreasing average porosity, as illustrated in Figs. 4 and 5 and tabulated in Table V. Groups *A*, *B*, and *C* are composed of clays with

TABLE V

GROUPING ACCORDING TO PROPERTIES OF FIRED CLAY

Clay Numbers		Fired at 1150°C	1180°C	1230°C	1270°C	1310°C
Group *A* 2, 3, 6, 7, 16, 19, 23, 30, 31, 46.	Modulus of rupture lbs./in.²	740	870	970	1160	1250
	Porosity per cent	39.2	39.0	35.2	31.5	34.0
Group *B* 1, 8, 9, 10, 12, 14, 21, 22, 24, 25, 26, 27, 29, 40, 41, 43, 44, 47, 48, 49, 50.	Modulus of rupture lbs./in.²	2040	2220	2590	2930	3050
	Porosity per cent	30.0	29.7	26.5	22.2	23.7
Group *C* 5, 32, 35,	Modulus of rupture lbs./in.²	2830	3210	3130	3020	3530*
	Porosity per cent	21.9	20.0	15.0	16.1	14.8
Group *D* 18, 36, 37,	Modulus of rupture lbs./in.²	3650	3690	3970	3600	4420*
	Porosity per cent	22.1	20.4	13.9	7.6	12.2
Group *E* 15, 38, 39,	Modulus of rupture lbs./in.²	2600	2770	3480	4420	4500
	Porosity per cent	29.3	29.0	22.5	9.3	12.6

* Average of two clays only in 1310°C firing.

satisfactory firing properties, group *D* might be considered fair, while group *E* contains clays with decidedly undesirable firing properties.

For convenience the values given in Table V are roughly summarized as follows:

Group	Modulus of Rupture Lbs./in.²	Porosity Per cent
A	Less than 1500	30–40
B	Between 1500–3000	23–30
C	Between 2800–3500	14–23
D	Between 3500–4500	7–23
E	Between 2500–4500	7–30

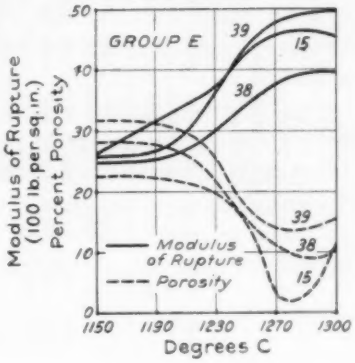

FIG. 5.

Supplementary Tests

In order to study progressive changes which may take place in sagger bodies in the course of successive firings, 125 bars were prepared, composed of 75% clay and 25% grog, of each of two clays and a mixture of the two in equal proportions, and a similar number of bars of each of three clays and a mixture of the three in equal proportions. These bars (representative of commercial sagger bodies) were then submitted to the Warwick China Company and the Crooksville China Company where they were placed in saggers with regular ware and subjected to repeated firings at cone 11 in one pottery, and at cone 9 in the other. Ten specimens of each clay or body were returned to the Bureau of Standards at the end of each firing for the first five consecutive firings and thereafter at intervals of three firings until the final specimens had received 17 firings by the one pottery and 26 firings by the other.

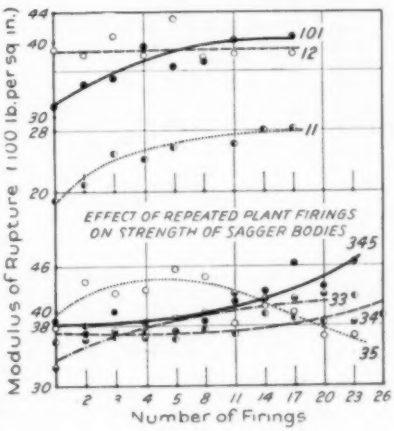

FIG. 6.

Progressive changes in physical properties due to repeated firings are given in Table VI, and the change in modulus of rupture is illustrated in Fig. 6. These may be summarized as follows:

Clay 11: marked increase in transverse strength and a decrease in porosity.

Clay 12: very little change in transverse strength, but a decided increase in porosity and a possible overfiring after 11 firings.

TABLE VI

SPECIMENS FIRED IN COMMERCIAL KILNS

Firing	Porosity in Per Cent, Average on three specimens, Clay Numbers						Volume Shrinkage in Per Cent, Average on three specimens, Clay Numbers						Modulus of Rupture (Lbs./sq. in.), Average on 8 to 10 specimens, Clay Numbers					
	11	12	101	33	34	35	345	11	12	101	33	34	35	345	11	12	101	33	34	35	345
1	34.4	21.1	29.8	24.2	19.7	6.0	15.6	26.0	20.0	22.1	23.2	19.3	21.9	22.0	1890	3910	3150	3270	3610	3820	3820
2	33.5	19.0	26.8	22.7	21.3	5.4	15.5	27.6	21.4	23.6	23.7	17.8	22.1	22.2	2100	3820	3430	3650	3770	4410	3860
3	31.4	14.6	24.6	19.7	20.7	4.5	12.2	29.5	22.1	24.1	24.5	18.3	22.4	22.4	2520	4080	3520	3720	3670	4240	4010
4	30.2	14.5	23.7	18.2	21.1	5.2	13.6	30.2	22.8	25.0	25.2	18.5	22.2	22.3	2540	3810	3950	3670	3730	4280	3860
5	30.5	14.0	24.4	17.9	19.4	3.9	12.6	30.7	22.7	24.9	25.1	18.6	22.6	22.5	2570	4320	3680	3640	3680	4530	3810
8	32.8	12.1	22.1	19.5	14.0	6.2	12.4	—	—	—	—	—	—	—	3090	3780	3760	3920	3850	4450	3880
11	31.8	11.7	17.2	16.8	13.9	7.4	11.3	—	—	—	—	—	—	—	2650	3830	4020	4000	3710	3820	4140
14	30.1	14.7	20.2	20.0	17.9	8.1	12.9	—	—	—	—	—	—	—	2820	3410	3510	4240	3960	4060	4270
17	30.0	15.3	22.0	20.7	18.5	8.6	12.4	—	—	—	—	—	—	—	2830	3840	4090	4150	3960	3920	4650
20	—	—	—	19.3	17.8	9.2	12.3	—	—	—	—	—	—	—	—	—	—	4180	3870	3660	4340
23	—	—	—	17.6	17.8	10.4	11.4	—	—	—	—	—	—	—	—	—	—	4220	4200	3690	4660
26	—	—	—	—	17.3	11.4	10.5	—	—	—	—	—	—	—	—	—	—	3840	3970	—	4170

Clays 11, 12, 101 fired to cone 11.
Clays 33, 34, 35, 345 fired to cone 9.

Body 101: representing an equal mixture of clays 11 and 12; increase in transverse strength, a marked decrease in porosity and possible overfiring after 11 firings. The data indicate that fired specimens of this body had greater strength at the end of the test than fired specimens of either of the individual clays.

Clays 33 and 34: increasing transverse strength with a decrease in porosity.

Clay 35: overfired; after five firings a decrease in transverse strength and an increase in porosity indicating a short vitrification range.

Body 345: representing an equal mixture of clays 33, 34 and 35; increase in transverse strength and a decrease in porosity. The average modulus of rupture of fired specimens of this body is greater than that of fired specimens of any of the three individual clays.

The petrographic examination of body 345 showed incipient mullite needles at the end of the first firing. These became more pronounced with succeeding firings, and glass, present in considerable quantities in the first firing, also increased in the following firings. The petrographic examination of clay 33 showed progressive changes with repeated firings. The first trace of mullite appeared at the end of 11 firings, with a gradually increasing amount appearing with succeeding firings. A notable increase in glass content appeared in the specimen subjected to eight firings, with a gradually increasing amount appearing in succeeding firings, indicating the approach of complete vitrification.

Although mullite is formed in these clays by repeated firings, no conclusion has been reached relative to the effect of this crystal growth on the strength of the clays. However, the increase in the quantity of glass due to repeated firings undoubtedly increases the modulus of rupture when determined by breaking slowly cooled specimens, but very probably this increase in the quantity of glass causes a weakening of the structure under load at high temperatures, due to the glass being in a mobile state. Therefore, although the cold modulus of rupture is shown to be increased in these bodies by repeated firing, the structure at kiln temperatures may actually be weaker due to the greater content of glass.

Future Work

Having obtained sufficient data to group or classify the clays included in the investigation, it is now proposed to take, from each group (*A*, *B*, *C*, *D* and *E*), three clays having the highest, lowest and a medium resistance to failure in the dunting test and subject them to an intensive study.

It is hoped that the information gained from the work outlined will be sufficiently conclusive to warrant its application to plant practice.

THE DESIGN OF ARCHES FOR KILNS AND FURNACES[1]

By F. H. Norton[2]

ABSTRACT

The design of arches is considered from the view point of minimizing the static and temperature stresses. The catenary shape of arch is most satisfactory, as it allows the use of a high arch with good stability. Some actual designs are worked out to illustrate the method of calculating a catenary arch.

Introduction

The design of high temperature arches has not hitherto received as careful study as the usual masonry arch. There are a number of excellent treatises[3] on the latter type of arch but they are of little assistance because of the different construction in the two cases.

The masonry arch generally has a stiff spandrel backing and strong mortar joints so that the stability of the arch ring alone is not of primary importance. On the other hand the furnace arch is a relatively slender ring with no support except at the skewbacks, and the joints cannot be depended upon to take tension. This makes the computation of the static stresses quite simple, but the temperature stresses can only be approximated.

Static Stresses in Circular Arches

Let us first consider the mean stress over a unit section in a circular arch ring at the skewback and at the crown. Referring to Fig. 1, the load on the skewback, parallel to the direction of the ring, is;

$$R = w \operatorname{cosec} \theta \qquad (1)$$

and the compression at the crown is:

$$H = w \cot \theta \qquad (2)$$

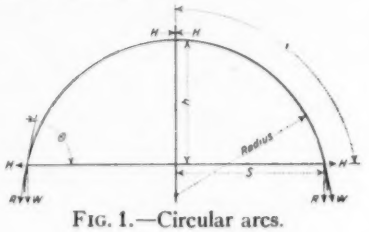

FIG. 1.—Circular arcs.

where

θ = angle of ring with horizontal at skewback

w = weight of a slice of the arch one unit long and extending from the crown to the skewback, $= Wl$, where W equals the weight of a unit block taken in a plane tangent to the arch.

l = semi-arc,

h = rise,

s = semi-span.

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlantic, Ga., Feb., 1926. (Glass-Refractories Symposium.) Recd. Nov. 17, 1925.

[2] Babcock and Wilcox Fellow, Division of Industrial Coöperation and Research, Massachusetts Institute of Technology.

[3] Baker, A Treatise on Masonry Construction.
Allan, Theory of Construction.
Howe, Symmetrical Masonry Arches.
Sondericker, Graphic Statics.

The increase in loads due to flattening the arch is shown in the following table:

TABLE I

$\frac{s}{h}$	l	w	θ	cosec θ	cot θ	R	H
1	1.57	1.57	90°	1.00	0.00	1.57	0.00
2	1.16	1.16	53	1.25	0.75	1.45	0.87
4	1.03	1.03	28	2.13	1.88	2.19	1.94
8	1.01	1.01	14.2	4.06	3.95	4.06	3.96
16	1.00	1.00	7.1	8.08	8.03	8.08	8.03
32	1.00	1.00	3.5	16.00	16.00	16.00	16.00
			$s=1$		$w=1$		

It will be noticed that R is a minimum when $\frac{s}{h}$ is about 1.8.

The average stresses have been considered above, but the stresses due to eccentric loading may be much larger, especially in the higher arches. The centers of thrust on the arch bricks will lie on a catenary curve when the crown is of uniform weight. By finding the difference between a circle and a catenary, the eccentricity and increased load can be determined. This has been worked out in the following table:

TABLE II

$\frac{s}{h}$	Difference between circle and, catenary at crown and skew-back in terms of s.	Stress factor when thickness of ring is		
		0.15	.055	.0255
1	0.045	2.35	unstable	unstable
2	0.030	1.90	2.80	unstable
4	0.005	1.15	1.30	1.60
8	0.000	1.00	1.00	1.00
16	0.000	1.00	1.00	1.00
32	0.000	1.00	1.00	1.00

$s=1$

The intensity of stress was computed from:

$$f=\frac{P}{A}(1+3\frac{d}{b}) \tag{3}$$

where;

P = the average load
A = the unit area
d = is the distance of the load line from the neutral axis
b = ½ the thickness of the ring

In Table II the factor $(1+3\frac{d}{b})$ is given to show how the loads in Table I are increasing in the higher arches by considering the eccentric loading. In fact, some of the cases considered are actually unstable. $(d>b)$

Static Stresses in Catenary Arches

As the load line in an arch of uniform weight is approximately a catenary it is clear that the form of arch having a minimum of stresses is a catenary. Table III has been prepared for a series of catenary arches similar to Table I for circular arches.

TABLE III

$\frac{s}{h}$	l	w	θ	R	H
1	1.49	1.49	67.4°	1.61	0.62
2	1.16	1.16	47.5	1.43	1.06
4	1.04	1.04	27.5	2.33	2.01
8	1.01	1.01	14.2	4.10	4.00
16	1.00	1.00	7.1	8.08	8.00
32	1.00	1.00	3.5	16.20	16.00

It will be noticed that the average loads, R and H, as given in Tables I and III are approximately the same. However, the catenary has no eccentric loading and the stress factors given in Table II for the circle would be unity for the catenary in all cases.

Properties of the Catenary

It is rather difficult to find in one reference the various properties of the catenary, and computation of catenary arches has been considered difficult and laborious. However, if a few simple equations are used, any values can readily be obtained from tables.

The catenary is the curve taken by a uniform flexible chain hung between two supports. In the case of an arch the curve is inverted. An inverted catenary is shown in Fig. 2, plotted on the X and Y axis. The distance between the X axis and the apex of the curve is called the modulus (m) and determines the shape of the catenary.

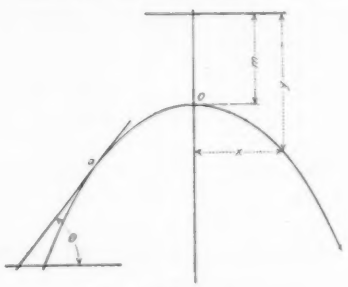

FIG. 2.—Catenary.

The equation of the catenary is:

$$y = \frac{m}{2}\left(\theta^{\frac{x}{m}} + e^{-\frac{x}{m}}\right) \tag{4}$$

or in hyperbolic functions

$$y = m \cos h \frac{x}{m} \tag{5}$$

The latter form is the most convenient to work with.

The slope angle at any point on the curve is given by:

$$\theta = \tan^{-1}\left(\sin h \frac{x}{m}\right) \tag{6}$$

The length of the curve between the apex and any point is:

$$l = m \sin h \frac{x}{m} \tag{7}$$

The radius of curvature at any point is: $r = \frac{y^2}{m}$

The compression (or tension) at the apex is:

$$H = wm$$

where w is the weight per unit length of the curve.

It is usually desirable to find a catenary that will pass through three given points, the crown and two skewbacks. That is, we have values of x and $y-m$, and wish to find m.

From equation (5), $(y-m)+m = m \cos h \frac{x}{m}$.

It is difficult to solve directly for m in the above equation, so a value for m must be assumed and the equation evaluated. If the two sides are not equal another value must be taken, and so on until a sufficiently precise value is obtained. Much time can be saved by obtaining the initial value of m from the curve in Fig. 3 to suit the ratio of rise to span.

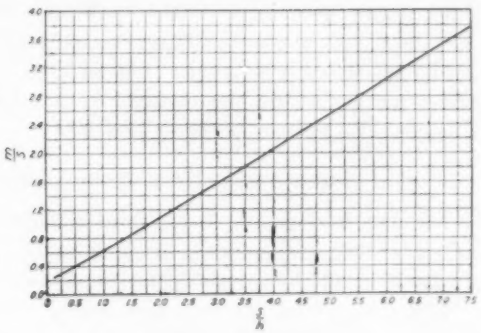

FIG. 3.—Curve for obtaining modulus
Where $s = \frac{1}{2}$ span
h = rise
m = modulus

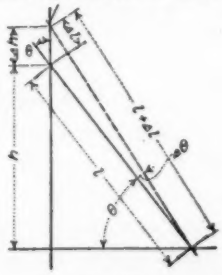

FIG. 4.—Temperature stresses. Change in length.

Temperature Stresses

If a crown is held rigidly between skewbacks and is heated it must rise to a certain extent. This rise causes an increase in curvature at some or all points and therefore pinches the tips of the arch blocks. The exact amount of this rise cannot be calculated because the points of flexure are not determinate. The relative amount

for different heights of crown can be calculated as shown in Fig. 4. The increase in height, $\Delta h = \Delta l$ cosec θ, relative values of which are given below.

TABLE IV

$\frac{s}{h}$	θ	cosec θ	Δh
1	45.0°	1.41	0.014
2	26.5	2.24	0.022
4	14.1	4.10	0.041
8	7.1	8.20	0.082
16	3.7	15.6	0.156
32	1.8	35.0	0.35

$s = 1$

The pinching effect is much more severe in flat arches than on high ones.

Another temperature stress is introduced by the unequal expansion of the inside and outside of the crown. This stress is a compression on the hot ends of the bricks.

Both of these temperature stresses tend to compress the hot end of the brick so that when the arch cools the inner ends of the joints are open. This causes instability and uneven stresses that often crack the blocks. The first temperature stress can be reduced greatly, as shown in Table IV by using a high crown. The second type of stress can be reduced by using insulation on the outside to cut down the temperature difference between the inner and outer surface.

Some Applications of the Catenary to Actual Design

For the first example suppose a crown is required for a rectangular kiln with 145 inches between skewbacks. From Table III it is seen that a rise of about 55 inches will give minimum values H and R together.

From Fig. 3 the approximate value of m is found to be 54.

$$(y-m)+m = m \cosh \frac{x}{m}$$

$$55+54 = 54 \cosh^{*} 1.34$$

$$109.0 = 54 \times 2.040$$

$$= 110.2$$

54 is a little too low; next trying 55.0 gives;

$$55.0+55.0 = 55.0 \cosh 1.318$$

$$= 55.0 \times 2.002$$

$$110.0 = 110.0$$

which is sufficiently exact.

It is convenient to tabulate the ordinates and abscissas as shown below. After m has been found it is only necessary to substitute in the various formulas.

* Smithsonian Mathematical Tables. Natural Hyperbolic Functions.

TABLE V

x	$\frac{x}{m}$	$\sin h\frac{x}{m}$	$\cos h\frac{x}{m}$	y	$y-m$	i	R
0	0	0	1.000	55.0	0	0	55.0
5	.0909	.0910	1.0041	55.2	0.2	5°15′	55.3
10	.1818	.1830	1.0166	55.8	0.8	10°22′	56.6
15	.2727	.276	1.0374	57.0	2.0	15°27′	58.9
20	.3639	.371	1.0670	58.7	3.7	20°21′	62.5
25	.454	.470	1.105	60.8	5.8	25°10′	67.1
30	.546	.574	1.153	63.5	8.5	29°52′	73.2
35	.637	.681	1.210	66.6	11.6	34°17′	80.6
40	.728	.794	1.277	70.2	15.2	38°29′	89.3
45	.818	.912	1.354	74.5	19.5	42°11′	100.8
50	.909	1.039	1.442	79.3	24.3	46°05′	114.2
55	1.000	1.175	1.543	84.9	29.9	49°37′	131.
60	1.091	1.321	1.657	91.1	36.1	52°52′	151.
65	1.182	1.477	1.784	98.2	43.2	55°52′	175.
70	1.272	1.644	1.924	105.8	50.8	58°42′	204.
72.5	1.318	1.734	2.001	110.0	55.0	60°02′	220.

From this table the curve can be laid out full size and the forms made up, allowing ½ the thickness of the arch ring inside the catenary.

The skewback angle is 60°02′.

As the radius of curvature varies between 55 and 220 it might be thought that a large number of special blocks would be needed with

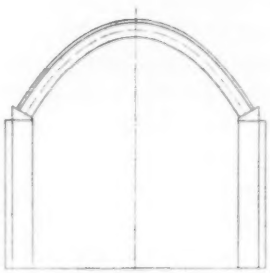

FIG. 5.

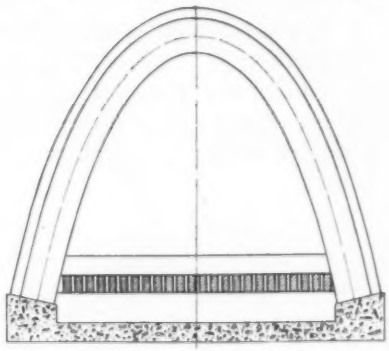

FIG. 6.

different tapers. It will be found, however, that if two tapers are provided, one to fit the short radius and one the long, they can be so alternated as to provide a satisfactory construction. The joints can be 10° or 15° from normal to the forms without harm as the angle at which slip occurs is about 30°.

This arch is shown to scale in Fig. 5 with a nine-inch ring and 2½ inches of insulation. The load at the skewback is 7.30 lbs. per sq. in. and at the crown 4.03 lbs. per sq. in.

As another example consider a high catenary for a small kiln so as to eliminate the sidewalls. The span will be 84 inches and the rise 69 inches. From Fig. 3, m is 20 and by trial as before more exactly 19.0.

TABLE VI

x	$\frac{x}{m}$	$\cos h\frac{x}{m}$	y	$y-m$
0	0	1.000	19.0	0
5	0.263	1.035	19.7	7
10	0.527	1.142	21.7	2.6
15	0.789	1.328	25.2	6.2
20	1.054	1.609	30.6	11.6
25	1.317	2.000	38.0	19.0
30	1.579	2.528	48.1	29.1
35	1.841	3.231	61.4	42.4
40	2.108	4.177	79.5	60.5
42	2.210	4.613	88.0	69.0
		$m=19$		

This arch is shown to scale in Fig. 6.

Conclusions

It may be concluded from the above discussion that:

1. High arches have a minimum of static and temperature stresses.
2. High circular arches approach instability and, therefore, are unsatisfactory.
3. High arches of catenary shape are quite satisfactory.
4. Insulation of the crown decreases the temperature stresses.

A number of catenary arches have been tried out on high temperature kilns in direct comparison with circular arches. In every instance they have shown several times the life of the circular arches.

A PRACTICAL GAS-FIRED TEST FURNACE FOR PLANT USE[1]

By H. G. Fisk[2]

ABSTRACT

A gas-fired test furnace of quite general application is described.

Introduction

Many plants have need for a small test furnace for fusion, firing, spalling, slagging and load tests. This article describes a furnace which has proved to be of quite general application, low in construction costs and operating costs, and efficient with either low pressure, natural or artificial gas.

Most furnaces require compressed air not available at many plants. Other furnaces operate by a blower but their use is restricted due to their small size, difficulty in making observations while in operation and in the temperature attainable. The furnace here described overcomes these difficulties.

Construction

The furnace is of the pot type; it is updraft, direct-fired, with two burners arranged tangentially at the bottom. The inside of the furnace is constructed of a ring of arch brick, set on end, forming a circle of approximately twelve inches inside diameter. Resting on the lower ring, a second ring is set in a circle of about nine inches inside diameter. The lower inside edge of the top circle of brick is tapered downward on the inside. (See Fig. 1.) First grade heavy duty fire brick are used for the inside rings which are insulated by outer rings of less refractory brick. Midway and above the points at which the burners enter the furnace, and opposite the blower, is a door of such size that the end of a standard size brick may be inserted on edge. This door is for observation and insertion of trial pieces.

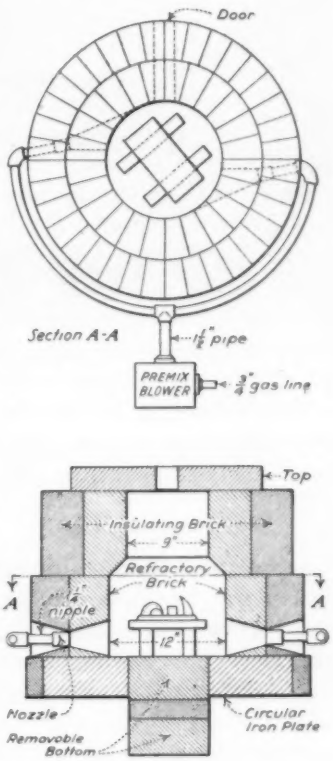

FIG. 1.

The burners enter from opposite sides, and are offset to give a rotary effect to the gases within the chamber. The burner nozzles

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb., 1926. (Refractories Division.)

[2] Crescent Brick Company, New Cumberland, W. Va.

are flush with the inside of the outer ring of brick and the ports are tapered through the inside ring to allow expansion of combusting gases. The nozzles are sealed with alundum cement. This makes possible operation with greater positive pressure. The mixing blower is set close to the furnace in such a manner as to allow equal distribution to each burner through a one and one-half inch pipe. These pipes are bent to avoid unnecessary sharp turns. The bottom of the furnace is so built as to permit removal to make repairs from the bottom, and to inspect the burner ports from the inside. The direct support of the bottom by bricks from the foundation gives ample rigidity for a load test. The furnace is mounted on a one-half inch thick iron plate with a nine and one-half inch square hole in it to allow the removal of the bottom. The mixing blower, a Maxon Premix Blower No. 5, is operated on 220 or 110 volt alternating or direct current. Iron bands are placed around the outside as shown in Fig. 2 to give strength and rigidity.

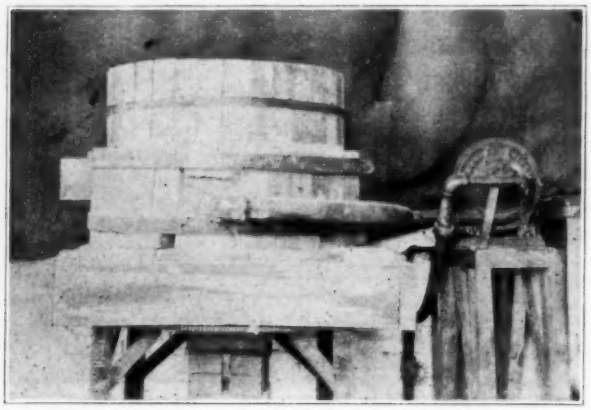

FIG. 2.

Operation

A heating effect equivalent to cone 20 is obtained without any obstruction to the flow of gases in the chamber, but to obtain cone 30 it is necessary to place a checker or box work in the chamber to hold the heat. This checker work can be made to form a muffle protection for test pieces and cone plaques. The best grade of aluminous or flint fireclay brick cut to appropriate sizes has been found to give satisfaction here. In order to constrict the flow of gases from the top of the combustion chamber and to allow a draft adjustment four bricks are set end to side so as to form a hole about 3 inches square over the center of the chamber. These brick permit a variation of draft at will. If desired, two soaps may be placed in the door and observations made by the removal of the top one only. For a spall test the brick to be tested, of standard size, is inserted in the door and withdrawn at intervals for immersions or chillings. The removable bottom permits the tapping

of heated or molten charges into water. This permits the preparation of frits and increases the range of usefulness of this installation. Temperature readings may be made through the door with an optical pyrometer, or a thermoelement.

It has been found that at temperatures around cone 30 the checker brick deform due to load and spall due to sudden temperature changes caused by opening the door. The best service at these temperatures has been obtained from cyanite brick.[1] It is thought that temperatures above cone 30 could readily be obtained by the use of carborundum brick for the boxing, as the limiting factor has been the stability of the checker work rather than the temperature of combustion.

Advantages

This furnace has the advantage of allowing rapid heat tests to be made under either oxidizing, neutral or reducing conditions on large or small test pieces. The firing chamber is sufficiently large to accommodate standard size brick. Continuous operation without the necessity of shutting down for the making of observations from the top is possible. It is of rugged construction and will stand considerable abuse. Samples may be withdrawn and introduced through the door without the necessity of allowing the furnace to cool completely, thus making possible a greater number of tests in a given time. There are no expensive parts or shapes to be replaced. The operation on natural gas of pressures as low as two ounces is a decided advantage.

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[1] Cyanite brick, kindly placed at the author's disposal by H. C. Harrison of the U. S. Bureau of Mines.

A CHEMICAL STUDY OF THE ABSORPTION OF SULPHUR DIOXIDE FROM KILN GASES BY CERAMIC WARE[1]

By Frederick G. Jackson[2]

ABSTRACT

Two clays rich in scum-forming bases are studied. One is practically free from sulphur, the other heavily charged with it. Draw trials of these clays are taken from laboratory and commercial kilns at suitable temperature intervals. Commercial firings typify minimum, average and extreme sulphur exposure in coal-fired kilns. Laboratory firings are in imitation of them. The draw trials are analyzed for water-soluble sulphates and bases and the percentages of the appropriate sulphates are presented in the form of tables.

Comparisons of results show that the temperature attained has much more influence on the amount of sulphates formed in the ware than concentration, or time of sulphur exposure. Calculations show that even under the most favorable firing conditions, with 0.5% sulphur coal on a 64-hour schedule of firing, twelve times as much sulphur is available as is actually absorbed. Even under the most severe conditions the concentration of sulphur gases from the coal in the kiln gases is so small, (1%), and the maximum evolution of sulphur gases from the ware is such a small fraction (2.6%) of the volume of kiln gases, that the effect of the former in retarding the formation of the latter according to the Law of Mass Action, must be unnoticeable. It is, therefore, futile to try to avoid sulphate formation with coal as a fuel by seeking a coal low in sulphur. The method of study used is recommended for intensive investigation of firing conditions with the object of attaining maximum economies.

Introduction

The presence of sulphur dioxide in kiln gases has long been known to have a bad effect on ceramic ware. It was early recognized as a cause of scumming by Seger[3] and by Trautwine.[4] Orton[5] has shown the behavior of iron-sulphur compounds present in green ware under various conditions of firing. Previous work by the writer[6] has shown that the sulphur may be present in the ware as any of a variety of compounds. However, the distribution of sulphate between the various bases at different stages of the firing, while hinted at by Orton and Staley, has never been studied quantitatively.

Object of the Investigation

The practical man wants to know how to mature his ware and get it free from sulphur. He wants to do this as quickly and as cheaply as

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[1] Published by permission of the Acting Director, Bureau of Mines, Department of Commerce. Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb., 1926. (Heavy Clay Products Division.) Received December 31, 1925.

[2] Associate Chemist, Bureau of Mines, Ceramic Station, Columbus, Ohio.

[3] Collected Writings, I, 213.

[4] *Jour. Franklin Inst.*, **105**, 259 (1878).

[5] Orton and Staley, "A Study of the Chemical Status of Carbon, Iron and Sulphur in Clays during the Various Stages of Burning." Third Report of the Committee of Technical Investigation N.B.M.A., 1908.

[6] *Jour. Amer. Ceram. Soc.*, **7** [3], 163; [4], 223; [5], 382; [6], 427; [7], 532; [8], 634; [9], 656 (1924).

possible. This process resolves itself into several steps. If the fuel contains sulphur, this will be carried into the kiln principally as dioxide. At first this will be oxidized and absorbed by the ware as sulphates if bases are present. At higher temperatures the sulphur gas will (theoretically) resist the decomposition of these sulphates. If the ware contains sulphur in the form of pyrite, this sulphur must be oxidized. One step in its removal is the formation of sulphates. If these sulphates are not subsequently broken down they may cause bloating and black[1] or red[2] cores in the ware. Sulphates remaining in the finished ware will cause scumming and efflorescence.[3]

This investigation is planned to determine the fundamental processes behind these phenomena. The presence of sulphates in the ware during various periods of the firing is the key to the situation. This investigation is, therefore, a study of the sulphates present in clays during firing. The following questions present themselves; when a clay containing compounds of iron, calcium, magnesium, and the alkalis, is exposed to a sulphurous kiln atmosphere, with which base does the sulphur combine? When pyrite oxidized in such a clay, is there any interchange of bases such as $2FeS_2+MgCO_3+6O_2=Fe_2O_3+MgSO_4+3SO_2+CO_2$? Is there any direct change of bases due to increased temperature, such as $Fe_2(SO_4)_3+3CaCO_3=3CaSO_4+Fe_2O_3+3CO_2$? Can scumming be reduced by changing from a fuel containing much sulphur to one containing only a little? Does the formation of a scum-forming or effloresing compound require for its formation the intermediate action of some other compound?

The answers to some of these questions may be found by a study of draw-trials from commercial kilns. For comparative results, it is necessary to make tests with the same clay as draw-trials from several different kilns in which the heat treatment is different and with two otherwise similar clays, one containing pyrite and the other practically free from it.

Selection of Material

In selecting clays for such a study, it is important that all of the bases to be studied should be present in sufficient amount to be able to play their proper parts. Two coal-formation clays were selected from the descriptions and analyses of many such given in "Coal Formation Clays of Ohio."[4] One was an Upper Freeport clay from Dennison,

[1] Orton and Staley, *loc. cit.*

[2] M. C. Booze, "The Effect of Red Hearts in Fireclay Brick." *Jour. Amer. Ceram. Soc.*, **8** [4], 227 (1925).

[3] See F. G. Jackson, "A Descriptive Bibliography of Scumming and Efflorescence," *Bull. Amer. Ceram. Soc.*, **4** [8], 376 (1925).

[4] Geological Survey of Ohio, fourth series, *Bulletin*, **26** (1925).

Ohio, the other a middle Kittanning clay from Zanesville, Ohio. Microscopic examination showed that the Upper Freeport clay contained abundant siderite ($FeCO_3$) but little pyrite. Pyrite (FeS_2) was freely present in the middle Kittanning sample.

ANALYSES

	Upper Freeport	Middle Kittanning		Upper Freeport	Middle Kittanning
SiO_2	57.96	50.05	Na_2O	.51	.14
Al_2O_3	20.78	21.73	K_2O	2.74	3.90
Fe_2O_3	6.18	7.95	S	.05	.87
CaO	.37	.56	Total C	.85	.45
MgO	1.10	1.66	Inorganic C	.51	.14

*As given in "Coal Formation Clays of Ohio"

Commercial Uses

While both of these clays were used commercially, neither one was used without admixture. The Upper Freeport clay was mixed with an equal quantity of shale for making sewer pipe, the Middle Kittanning clay was added to nine parts of shale in making common and paving brick. It was extremely plastic and was introduced to increase the plasticity of the mixture.

Method of Procedure

Several hundred pounds of each variety of clay were made up into test bricks of special size, ($2\frac{1}{2}$x$2\frac{1}{2}$x7 inches). Several series of tests were made on these in a miniature round downdraft kiln in the laboratory. This kiln was an exact reproduction of a normal 30 ft. kiln with all dimensions reduced from feet to inches and the diameter then halved again making a kiln 15 inches in diameter. The kiln (Figs. 1 and 2) was fired with natural gas from eight bunsen burners which

FIG. 1.—Miniature kiln.

were fed through a manifold. The gas consumption was measured to thousandths of a cubic foot. A device installed between meter and manifold permitted the introduction into the fuel gas of controlled amounts of sulphur dioxide. By this means the sulphur content of commercial kiln atmospheres could be imitated. In the following tests, reproductions were made of kiln atmospheres where coal containing 1%, 4% and 5% of sulphur were imitated. Also, a series on the pyritic clay with a sulphur free atmosphere. Each test represents a separate firing.

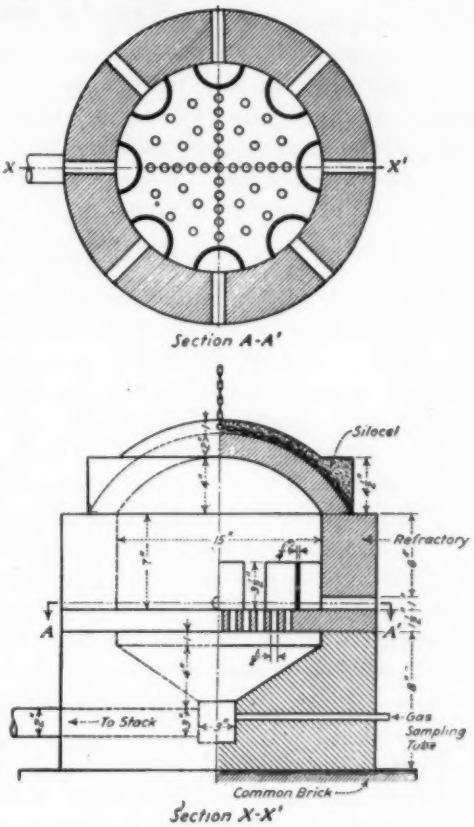

FIG. 2.—Miniature kiln.

In calculating the amounts of SO_2 to be introduced into the gas for these tests, the concentration of SO_2 in the kiln atmosphere was made to correspond to that in a coal-fired kiln. With natural gas as a fuel however, the proportion of hydrogen is so great that considerably less bulk of atmosphere need be passed through the kiln per square foot of kiln floor to effect a definite rise of temperature than with coal as fuel. For comparative purposes it is thus the effect of concentration rather than the amount of SO_2 that is studied.

Method of Sampling

After each firing, a test brick from the center of the kiln next to the thermocouple was removed. A rectangle 2 inches x 1 inch was marked off on one face. Inside this the material was dug out with a cold chisel to an even depth until about 9 grams has been obtained. This was ground fine in a porcelain mortar and put on a balance pan. About two grams more of material were then removed from the bottom of the hole, ground, and added to the first lot until exactly 10 grams were

obtained. In this way all samples were practically uniform in regard to amount of exposed surface included and depth of sampling.

Method of Analysis

These ten-gram samples were then boiled for 30 minutes with 500 cc. of distilled water. They were cooled and allowed to settle over night. Then the water extract was filtered off and refiltered until clear. The clear extracts were each divided into two equal portions, one portion was analyzed for sulphur, the other for acidity, iron and aluminum, calcium and magnesium.[1]

Results

The results of these analyses can best be presented in tabular form. In Table I is given the elapsed time, the temperature, (°F will be used throughout) and the number of grams of sulphur that had entered the kiln per 2 square inches of kiln floor. This unit was selected so that results from kilns of different sizes could be compared and the actual amount of SO_2 impinging upon the amount of surface taken for analysis could be seen. The actual percentages of the different sulphates formed as calculated from the oxides found are then given.

Iron and alumina were determined together and calculated as ferric sulphate. This was done for simplicity. It seemed unnecessary to distinguish between the two. The SO_3 required to form these sulphates is subtracted from the total SO_3 and the remaining SO_3 is calculated to K_2SO_4 because it seemed probable, on account of the large amount of potash present, that potash was the base with which this SO_3 was combined.

These figures point toward some rather surprising conclusions. Confirmatory tests were therefore made in commercial kilns and the results of these will be presented before any discussion is taken up.

Commercial Kiln Tests

Tests were made in three different commercial kilns. In these the sulphur contents of the coals used, the nature of the kiln charges, and the duration of firing were greatly divergent. The first kiln was fired with 32,000 pounds of coal containing 0.5% volatile sulphur. It was 30 feet in diameter, had 8 dead-bottom fire boxes and was charged with 108,000 pounds of drain tile. A temperature of 1790°F was attained in 64 hours.

The second kiln was fired with 25,600 pounds of coal containing 1.0% volatile sulphur. It was 32 feet in diameter, had 9 dead-bottom

[1] In these dilutions, the limit of solubility of calcium sulphate, 1 gm. in 500 cc. was not approached. Although but slightly soluble, it forms scum and efflorescence like the more soluble salts and is properly classified among them.

fire boxes and was charged with 87,000 pounds of sewer pipe, mostly 12 inch. A temperature of 1855°F was attained in 90 hours. The Upper Freeport clay was alone tested in this kiln.

The third kiln was fired with 95,680 pounds of coal containing 5.0% volatile sulphur. It was 30 feet in diameter, had eight inclined grate fire boxes and was charged with 23,400 common brick and 20,640 paving brick, total weight 325,040 pounds. Firing was kept up for 10 days, but 1840°F was reached in 177 hours with 64,850 pounds of coal. The test was stopped at this point.

TABLE I
TESTS IN MINIATURE KILN
Upper Freeport Clay

Draw trial no.	Time fired hrs.	Temp. °F	Gms. S 2 sq. in. floor	Fuel equiv. of atm. %S	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent $K_2(?)SO_4$	Per cent SO_3
0	0	unfired clay	0	0	.035	.010	.042	.141	.138
1	5	925	.067	¼	.070	.267	.144	.311	.478
2	5	925	.150	½	.080	.214	.150	.371	.492
3	5½	925	.201	¾	.095	.238	.174	.342	.514
4	4	770	.170	1	.055	.231	.066	.462	.452
5	5½	925	.277	1	.020	.371	.195	.583	.688
6	7	1075	.674	1	.070	.287	.126	.155	.386
7	3¾	795	.730	4	.070	.126	.057	.439	.412
8	5	925	.913	4	.075	.355	.150	.578	.694
9	5½	1075	1.30	4	.100	.529	.240	.284	.698
10	3¾	770	.99	5	.015	.146	.114	.644	.550
11	4	840	1.26	5	.075	.194	.078	.648	.542
12	6	925	1.71	5	.112	.389	.216	.473	.720
13	5	1075	1.88	5	.045	.199	.120	.272	.394

Method of Procedure

The method of procedure with each kiln was identical with minor exceptions. In the setting of the kiln, a little space was left before the wicket. Here, on a platform about 2 feet above the floor and 7 feet in from the wicket, the test pieces were piled. A base metal thermocouple was installed with its unprotected tip close to the test pieces. At appropriate intervals (generally eight or twelve hours) the temperature was read and a drawing was made of one of each variety of test piece. A close record was kept of the time and amount of coal added at each firing. It was then possible to calculate the amount of sulphur which had passed over the trial before it was drawn. This is shown in the tables of results.

The draw trials were sampled and the samples analyzed in exactly the same way as the trials from the miniature kiln. Results of analyses are given in the following tables. The two coal-formation clays were tested in the first kiln, the Upper Freeport clay alone was tested in the second, while in the third were the two clays and the factory mixture of 90% surface shale, 10% Middle Kittanning clay.

TABLE II
TESTS IN MINIATURE KILN
MIDDLE KITTANNING CLAY

Draw trial no.	Time fired hrs.	Temp. °F	Gms. S 2 sq. in. floor	Fuel equiv. of atm. %	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent H_2SO_4	Per cent $K_2(?)SO_4$	Per cent SO_3
0	0	unfired clay	0	0	.015	.233	.042	−.056	0	.118
1	2¼	755	0	0	0	.481	.114	0	.440	.620
2	4¼	840	0	0	.290	.860	.654	0	.028	1.156
3	5	990	0	0	.105	.753	.762	0	.350	1.200
4	6	1075	0	0	.195	.782	1.350	0	.505	1.770
5	6	1545	0	0	0	.782	.492	0	.338	1.028
6	9	1620	0	0	.150	.646	.276	0	.605	1.010
7	2¼	740	.170	1	.130	.379	0	0	.168	.400
8	4¼	840	.214	1	.150	1.035	.325	0	.673	1.290
9	5¼	990	.315	1	.065	.641	.180	0	.411	.778
10	6¼	1075	.441	1	.210	.884	1.350	0	.071	1.648
11	6	1420	.680	1	.655	.792	.390	0	.382	1.344
12	3¼	770	.995	5	.020	.714	.348	0	.187	.774
13	4	840	1.26	5	.090	.777	.474	0	.396	1.060
14	6	925	1.71	5	.212	.986	.900	0	.447	1.572
15	5	1075	1.88	5	.110	.753	.672	0	.502	1.252

Discussion of Results

Amounts of Sulphur Dioxide Absorbed

The most striking fact brought out by these data is the lack of absorption of increasing amounts of sulphur by the ware with increasing amounts of sulphur in the kiln atmosphere.

In Table I are shown the results of firing six samples of Upper Freeport clay to 925° in the miniature kiln with varying amounts of sulphur exposure. These results are compared with other tests of the same clay in commercial kilns to about the same temperature in Table IX.

In the tests in the miniature kiln, where the times of exposure are short and almost the same (5 to 6 hours) the percentages of sulphur absorbed in the extreme cases of ¼% S and 5% S (fuel equivalent atmospheres) are 0.340 and 0.582 respectively. These figures are in the ratio of 10 to 17. In the extreme case of exposure to 5% S for 81 hours, there is only 3.5 times as much absorbed as with ¼% sulphur in 5 hours. Analysis of the clay shows .37% CaO which would combine with .53% SO_3 and 1.10% MgO which would combine with 2.20% SO_3. There

are also 2.74% K_2O and 6.18% Fe_2O_3 which might act. The amount of SO_3 absorbed is therefore not limited by the amount of bases present but is almost entirely a function of temperature alone.

Considering now the case of Table I, test 5, where .277 gms. of sulphur per 2 square inches of kiln floor (1%S) entered the kiln. This amount of sulphur therefore impinged on the surface taken as a sample. If it had all been absorbed in the layer about $\frac{1}{4}$ inch deep which composed the sample, there would have been .6925 gms. of SO_3 formed. In the 10 gm. sample this would have been 6.925% SO_3. Analysis showed .688% SO_3 present. Therefore .550% SO_3 was absorbed: less than 8% of the possible amount of absorption. The proportion is almost the same in Table III, test 5, a commercial kiln test with the same concentration of sulphur. In the minimum case of $\frac{1}{4}$% S for 5 hours there was enough sulphur passing to have made 1.675% SO_3. 0.340% was taken up, or only 20%.

At the other extreme, in Table VI, test 6, 2.72 gms. of sulphur impinged on the area removed for sampling, equivalent to 6.80 gms. of SO_3 or 68.0% of the sample analyzed. Absorption was 1.196%. Therefore only 1.76% of the sulphur passing over the clay was retained as sulphate in the sample taken.

It is therefore evident that in any case at these temperatures, only a small proportion of the sulphur in the kiln atmosphere combines with only a small proportion of the available bases.

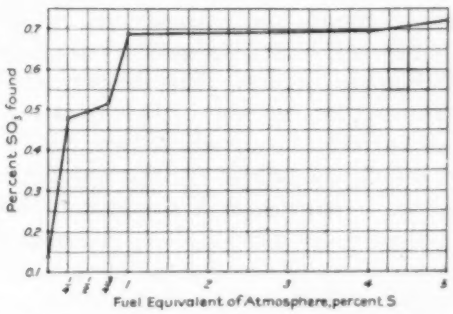

FIG. 3.—The effect of concentration of sulphur on amount of sulphur absorbed. Upper Freeport clay fired in miniature kiln in 5 to 6 hours to 925°.

Figure 3 shows the effect of changing the concentration of the sulphur in the kiln gases. The six tests plotted were all fired in the miniature kiln in 5–6 hours to 925°F with different sulphur contents of the kiln atmosphere. The percentage of SO_3 found on subsequent analysis in each case is plotted against the percentage of sulphur in a coal that would give a similar atmosphere to the one used.

The surprising point is brought out that a large proportion of the maximum absorption is brought about by kiln gas very low in sulphur content. Strange as it may seem, these determinations appear to point to the conclusion that variations in the sulphur content of coal within commercial limits will have little difference in effect on the amount of sulphur combined in the ware.

Let us compare these laboratory experiments with results found from commercial kilns. In such a comparison the element of time enters largely.

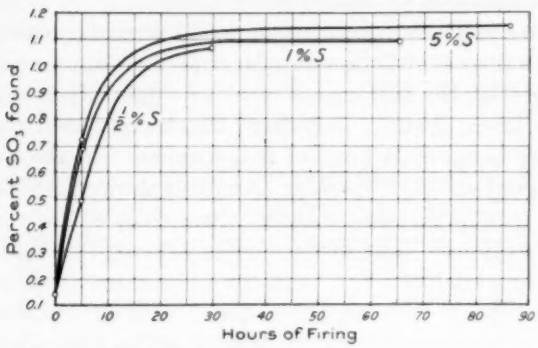

FIG. 4.—The effect of time of expourse to various concentrations of sulphur on the amount of sulphur absorbed.

The effect of time of exposure is shown in Fig. 4. Here the same sort of clay in all cases is fired to 925°F in various kilns. The percentage of SO_3 found is plotted against the time of firing. The curves connect points where the concentration of sulphur in the kiln atmosphere was the same.

The laboratory data are confirmed by these results and an additional point brought out. Variations in the time of firing to 925°, within commercial limits, as well as variations in the sulphur content of the coal, appear to exert little difference in effect on the amount of sulphur absorbed by the ware. This does not seem so impossible when it is realized that, as already shown, the ware exposed to ½% S coal gas for 29 hours was offered by this gas 12½ times as much sulphur as it accepted. With such a tremendous excess of sulphur present in the minimum commercial case, it seems reasonable that little more absorption would be caused by a great increase of this excess. But further evidence from commercial practice in this regard would be most valuable.

Conditions at other temperatures are compared in Table X. At 770°, with rapid heating, the concentration of sulphur has some effect. If the amount of SO_3 in the green clay is subtracted from the amount found in the first two tests cited, it is evident that five times as much sulphur in the gas has increased the amount absorbed in the ware by one third. Under two commercial conditions twice and one-half as much time or six times as much sulphur makes a difference of only 8% between one case and another. When laboratory tests are compared with commercial tests, the time factor is greatly varied. Such time differences at 770° exert a marked effect on the amount of sulphur absorbed.

Thus far we have been studying conditions when sulphur compounds are being absorbed. Above 1000°F the sulphates that have been formed

are decomposed. What effect has sulphur in the kiln atmosphere on these decompositions?

The decomposition of a sulphate by heat takes place according to the reaction:

$$MSO_4 = MO + SO_3$$

The Mass Action Law says that a reaction is retarded by the presence of one of its products, but the sulphur in the coal burns in the presence of carbon to SO_2. Inside the kiln, in the presence of glowing hot clay, a fairly good catalyst, there is some tendency for the equilibrium to be set up:

$$2SO_2 + O_2 \rightleftarrows 2SO_3$$

It is a good deal of a question, however, whether this would come at all close to equilibrium. When it is realized that the kiln gases from a coal containing 5% volatile sulphur burned with 100% excess air would contain only 1% by volume of SO_2 if all of the sulphur went to this compound, it is evident that there is only a small fraction of a per cent of SO_3 at the most in the gas.

TABLE III

UPPER FREEPORT CLAY FIRED ON 64-HOUR SCHEDULE WITH COAL CONTAINING 0.5% VOLATILE SULPHUR

Draw trial No.	Time elapsed hrs.	Temp. °F	Gms. S per 2 sq. in. floor	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent $K_2(?)SO_4$	Per cent H_2SO_4	Per cent SO_3
0	0	unfired clay	0	.035	.010	.042	.141	0	.138
1	22½	600	.315	.200	.078	.114	.296	0	.406
2	26	735	.390	.045	.325	.160	1.000	0	.902
3	27	775	.416	0	.306	.205	1.205	0	1.012
4	28	840	.434	.020	.442	.285	.910	0	.976
5	29	925	.478	.020	.549	.305	.910	0	1.072
6	30	990	.504	.035	.355	.198	.532	0	.665
7	31	1075	.548	.240	.277	.138	.070	0	.460
8	45	1545	.944	.260	.083	.141	0	−.178*	.154
9	52	1760	1.17	.105	.063	.126	0	−.086	.114
10	64	1790	1.49	.090	.044	.111	0	−.130	.048

* Negative amounts of sulphuric acid found by difference, are due either to slight experimental inaccuracies or to the formation of soluble salts of the bases other than sulphates.

Let us now assume that the bricks in the third commercial kiln tested (5% S coal) had all been made of Upper Freeport clay. This clay has very great absorptive power for sulphur. The weight of charge

was 325,040 pounds. This clay showed its greatest decomposition of sulphates between 105 hours and 117 hours in this firing. 0.712% SO_3 was evolved. If the entire kiln charge had lost at this rate, there would have been 2317 pounds SO_3 evolved, equivalent to 927 pounds of sulphur, during the twelve hours. During this interval 7100 pounds of coal were fired which contained 355 pounds sulphur. This sulphur, burning to SO_2, formed only 1% of the kiln atmosphere. Therefore the 927 pounds S evolved from the ware would form only 2.61% of the kiln atmosphere.

TABLE IV

MIDDLE KITTANNING CLAY FIRED ON 64-HOUR SCHEDULE WITH COAL CONTAINING 0.5% VOLATILE SULPHUR

Draw trial no.	Time elapsed hrs.	Temp. °F	Gms. S per 2 sq. in. floor	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent $K_2(?)SO_4$	Per cent H_2SO_4	Per cent SO_3
0	0	unfired clay		.015	.233	.042	0	−.056*	.118
1	22½	600	.315	.075	.288	.111	0	−.075	.228
2	26	735	.390	.525	.665	.588	.078	0	1.144
3	27	775	.416	.005	.282	.114	.097	0	.312
4	28	840	.434	0.000	.627	.396	.185	0	.742
5	29	925	.478	.830	.806	.792	.292	.098**	1.752
6	30	990	.504	.660	.844	1.074	−.061	.196**	1.732
7	31	1075	.548	.440	.933	1.134	−.121	.138**	1.610
8	45	1545	.944	.040	.547	.252	0	−.035*	.486
9	52	1760	1.170	.270	.277	.117	0	−.340*	.216

* See foot note to Table III.

** Positive amounts of sulphuric acid are found by actual titration. Slight deficiencies of SO_3 are calculated to K_2SO_4 in these cases for simplicity of expression.

While the small fraction of a per cent of SO_3 from the coal would undoubtedly retard the formation of this 2.61% SO_3 addition to the kiln atmosphere, according to the Law of Mass Action, it is very doubtful if the amount of this retardation could be noticed. Probably the strength of the odor has always deceived the kiln burner as to the concentration of the sulphur gases being evolved.

Selective Action of Sulphur Dioxide

The effect of time and concentration of sulphur dioxide on the selection of bases to form sulphates is an interesting study. The data for this study are assembled in Figs. 5, 6, and 7. In these figures the percentage of sulphate is plotted vertically against temperature. The elapsed firing time is noted below.

There is much of interest in these figures. Ferric sulphate was formed late and persisted long in the 64 hours firing (Table III) while it was reduced below 0.5% by the time 1250° was reached in the two slower commercial firings. Calcium sulphate reached a maximum in all three

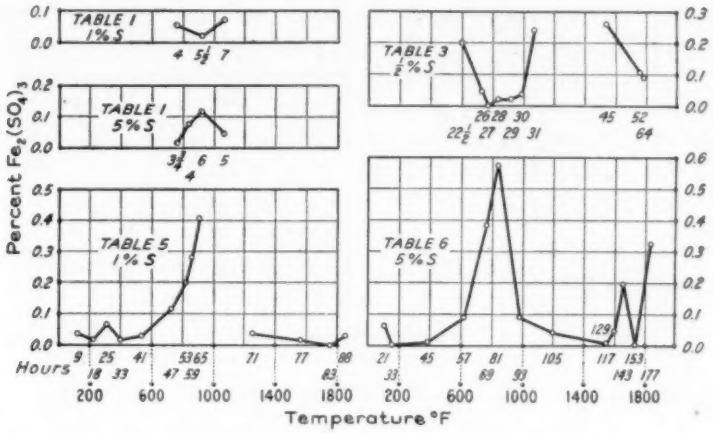

FIG. 5.—The effect of time and concentration of sulphur on the formation and decomposition of ferric sulphate with changing temperature.

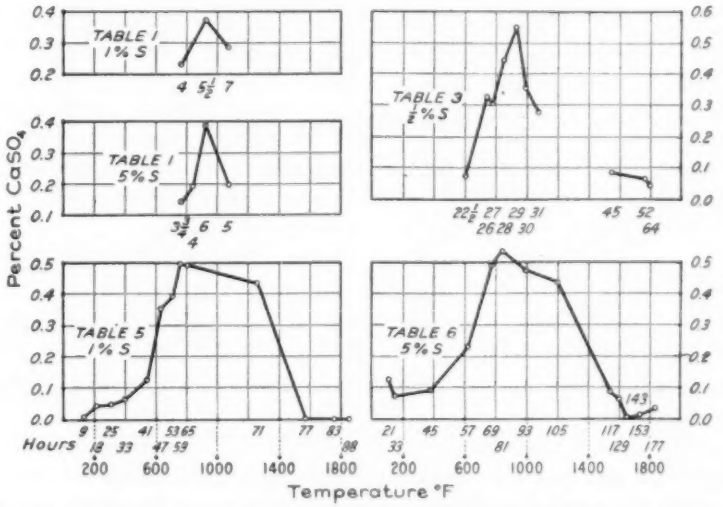

FIG. 6.—The effect of time and concentration of sulphur on the formation and decomposition of calcium sulphate with changing temperature.

firings between 750° and 950°. It then begins to decrease and is practically eliminated before 1600° is reached. This apparently is due to occasional short reducing periods caused by intermittent firing.[12]

[12] This decomposition by reduction has already been discussed in *Jour. Amer. Ceram. Soc.*, 7 [6], 427 (1924).

In spite of the 1.10% MgO in the green clay, only small fractions of a per cent of magnesium sulphate are formed except in the last case when the sulphur treatment was most severe. This seems to be due to the varied occurrence of the magnesium. Some of it is present as

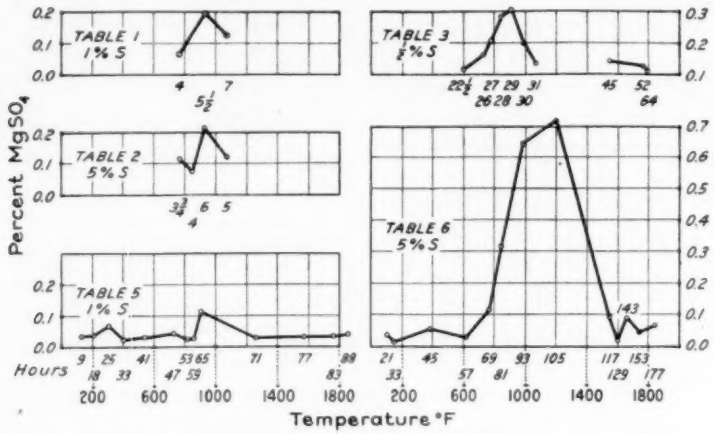

FIG. 7.—The effect of time and concentration of sulphur on the formation and decomposition of magnesium sulphate with changing temperature.

dolomite, easily attacked by sulphuric acid. The rest is combined as silicates which are either insoluble or decompose only slowly under prolonged attack of acids.

Middle Kittanning Clay

This clay presents a very different problem from the Upper Freeport. Heavily charged with pyrite, (0.87% S), it contains also 0.56% CaO and 1.66% MgO. These are all elements of trouble.

Decomposition of Pyrite

As has already been shown,[1] the decomposition of pyrite depends very greatly on the rate of gas flow over the ware. Quantitative comparisons between different kiln firings are therefore of little value. Data should be taken which are beyond the scope of this investigation in order to compare results.

It is interesting to notice in Table IV that the iron sulphate increased greatly from 600° to 735° and then decreased to nothing at 775° and 840°. This is probably due to the oxidation of some of the FeS_2 to sulphate. The heat of formation of this reaction then started the oxidation of the carbon in the clay. This resulted in a reduction of the sulphate to insoluble sulphide.

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[1] *Jour. Amer. Ceram. Soc.*, **8** [8], 534 (1925).

The two actions may be simply expressed as follows:

$$(600°\text{–}735°)\ FeS_2 + 3O_2 = FeSO_4 + SO_2$$
$$(735°\text{–}775°)\ FeSO_4 + 2C = FeS + 2CO_2$$

As soon as this carbon was burned out, the sulphide was again oxidized to sulphate. This sulphate then began to decompose to oxide as temperature increased. This phenomenon has already been brought out in studying the sulphur evolution from mixtures of pyrite and carbon with clay.[1] This step was not brought out in the results in Table VII. The above two reactions may have preceded oxidation during the 12 hours between the sample taken at 615° and that at 770°.

TABLE V

UPPER FREEPORT CLAY FIRED ON 90-HOUR SCHEDULE WITH COAL CONTAINING 1% VOLATILE SULPHUR

Draw trial no.	Time elapsed hrs.	Temp. °F	Gms. S 2 sq. in. floor	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent $K_2(?)SO_4$	Per cent SO_2
0	0	unfired clay	0	.035	.010	.042	.141	.138
1	9	130	.076	.035	.010	.033	.325	.240
2	18	212	.170	.015	.044	.039	.287	.230
3	25	310	.270	.065	.050	.066	.172	.214
4	33	400	.289	.015	.062	.021	.459	.330
5	41	540	.390	.020	.126	.030	.340	.306
6	47	735	.548	.115	.355	.042	.700	.718
7	53	810	.680	.200	.393	.024	.777	.824
8	59	860	.742	.280	.499	.027	1.035	1.088
9	65	905	.995	.405	.495	.111	.819	1.090
10	71	1260	1.30	.035	.432	.027	.826	.780
11	77	1575	1.56	.020	0	.030	.088	.084
12	83	1760	1.87	.000	0	.033	.109	.086
13	88	1855	2.08	.030	0	.039	− .037	.022

There was no free acid in any of these test pieces.

Calcium and Magnesium Sulphates

It is interesting to notice that this temporary formation of sulphate at 735° in Table IV was not confined to the iron. Calcium and magnesium sulphates were formed in even greater amounts. It is a question, however, whether these were formed in the other test pieces inside the kiln. There may have been free sulphuric acid developed which did not combine with bases inside the kiln before it was again decomposed

[1] *Loc. cit.*

by heat. During the laboratory treatment of the sample when the clay, containing dolomite, was boiled with water, the reaction

$$\left.\begin{matrix}CaCO_3\\MgCO_3\end{matrix}\right\}+2H_2SO_4=\left\{\begin{matrix}CaSO_4\\MgSO_4\end{matrix}\right.+2CO_2+2H_2O$$

would be bound to run to exhaustion of one of the factors. It is difficult to understand how calcium sulphate once formed at 735° could have been again reduced, even by carbon, at 775°.

TABLE VI

UPPER FREEPORT CLAY FIRED ON 200-HOUR SCHEDULE WITH COAL CONTAINING 5% VOLATILE SULPHUR

Draw trial no.	Time elapsed hrs.	Temp. °F.	Gms. S / 2 sq. in. floor	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent $K_2(?)SO_4$	Per cent H_2SO_4	Per cent SO_3
0	0	unfired clay	0	.035	.010	.042	.141	0	.138
1	21	110	.157	.060	.126	.036	.133	0	.212
2	33	155	.736	0	.073	.012	.376	0	.272
3	45	390	1.57	.010	.092	.054	.422	0	.344
4	57	615	2.01	.090	.231	.027	.539	0	.546
5	69	770	2.42	.385	.491	.111	.847	0	1.092
6	81	840	2.72	.575	.534	.312	.794	0	1.334
7	93	990	3.56	.090	.476	.642	.405	0	1.000
8	105	*	4.52	.040	.437	.714	.199	0	.886
9	117	1545	5.60	.005	.092	.090	.097	0	.174
10	129	*	6.61	.045	.068	.015	.087	0	.128
11	143	1655	7.73	.195	.010	.087	0	−.087	.110
12	153	1740	8.48	0	.015	.042	.049	0	.066
13	165	1740	9.28	.024	.141	.036	0	−.016	.110
14	177	1840	10.15	.324	.039	.063	0	−.263	.066

* The highly sulphurous kiln atmosphere destroyed the thermocouple and prevented a reading of temperature at these times.

Both calcium and magnesium sulphates are formed to a greater extent at the maxima and persist to higher temperatures in this clay than they did in Upper Freeport clay draw trials taken concurrently from commercial kilns.

A comparison of the results in Table IV with those in Table VII is of interest. In one case this clay, with its elements of trouble, was fired on a very rapid schedule with little exposure to sulphur fumes. In the other it was fired on a very slow schedule with as sulphurous a coal as is commonly used. The slow schedule developed the decomposition of pyrite at a lower temperature, so that at 840° the content of soluble sulphur was almost at its maximum while at the same temperature in

the rapid firing it was at less than half the maximum. However, when both kilns had reached 990° the soluble sulphur content in draw trials was in the ratio of 10 to 12 and the percentage of calcium sulphate, magnesium sulphate, and free sulphuric acid were in the same ratio. Therefore, seven times as much sulphur exposure had caused only 20% more sulphur absorption.

TABLE VII

MIDDLE KITTANNING CLAY FIRED ON 200-HOUR SCHEDULE WITH COAL CONTAINING 5% VOLATILE SULPHUR

Draw trial no.	Time elapsed hrs.	Temp. °F	Gms. S 2 sq. in. floor	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent $K_2(?)SO_4$	Per cent H_2SO_4	Per cent SO_3
0	0	unfired clay	0	.015	.233	.042	0	−.056	.118
1	21	110	.157	.030	.369	.027	0	−.167	.117
2	33	155	.736	.045	.330	.051	0	−.045	.218
3	45	390	1.57	.020	.452	.045	.029	0	.350
4	57	615	2.01	.025	.471	.048	084	0	.444
5	69	770	2.42	.665	.821	.312	.094	.100	.620
6	81	840	2.72	.805	1.020	.750	.211	.334	2.156
7	93	990	3.56	.540	1.025	1.290	.289	.235	2.390
8	105	*	4.52	.635	.913	1.548	.120	0	2.122
9	117	1545	5.60	.207	.733	.804	.036	0	1.148
10	129	*	6.61	.025	.539	.126	.025	0	.452
11	143	1655	7.73	.025	.296	.036	0	−.124**	.122
12	153	1740	8.48	.045	.126	.033	0	−.067	.068
13	165	1740	9.28	.050	.112	.078	0	−.091	.074
14	177	1840	10.15	.030	.019	.039	0	−.065	.002

* See note to Table VI.

** See note to Table III.

In advancing from 990° to 1545°, the fast kiln reduced the sulphur much more in 15 hours than the slow one did in 24. However, on the next stage, from 1545° to 1740°–60° the slow kiln more than regained the difference. A twelve-hour holding at this temperature in the slow kiln seems to have been of no benefit, to the surface of the ware at least. Although finished products were not obtained, it seems probable that properly matured ware could be produced in either kiln.

On the basis of these experiments, answers can be formulated to the questions suggested at the beginning of this paper.

When a clay containing compounds of iron, calcium, magnesium, and alkalis is exposed to a sulphurous kiln atmosphere, the sulphur combines with the different bases depending on the nature of the

TABLE VIII

90% SHALE 10% MIDDLE KITTANNING CLAY FIRED ON 200-HOUR SCHEDULE WITH COAL CONTAINING 5% VOLATILE SULPHUR

Draw trial no.	Time elapsed hrs.	Temp. °F	Gms. S 2 sq. in. floor	Per cent $(Al+Fe)_2(SO_4)_3$	Per cent $CaSO_4$	Per cent $MgSO_4$	Per cent $K_2(?)SO_4$	Per cent H_2SO_4	Per cent SO_2
0	0	unfired clay	0	.075	.180	.087	0	−.116	.114
1	21	110	.157	.050	.311	.018	.012	0	.232
2	33	155	.736	.035	.306	.003	.046	0	.230
3	45	390	1.57	.130	.340	.006	.146	0	.368
4	57	615	2.01	.135	.359	.246	.129	0	.388
5	69	700	2.42	.035	.665	.123	.748	0	.934
6	81	840	2.72	.205	.777	.546	.415	0	1.188
7	93	990	3.56	.155	.806	1.344	.165	0	1.560
8	105		4.52	.135	.738	1.368	.009	0	1.432
9	117	1545	5.60	.015	.685	.321	.092	0	.882
10	129		6.61	.010	.534	.108	0	−.002	.390
11	143	1655	7.73	.025	.476	.036	.022	0	.332
12	153	1740	8.48	.050	.238	.045	0	−.061	.150
13	165	1740	9.28	.045	.121	.033	.082	0	.168
14	177	1840	10.15	.045	.199	.024	0	−.044	.124

TABLE IX

UPPER FREEPORT CLAY FIRED IN VARIOUS KILNS TO APPROXIMATELY 925° F

Table no.	Test no.	Time fired hrs.	Temp. °F	Grams S 2 sq. in. floor	Fuel equiv. atm. per cent S	Per cent SO_2
0	0	0	unfired clay	0	0	.138
1	1	5	925	.067	$\frac{1}{4}$	.478
1	2	5	925	.150	$\frac{1}{2}$	.492
1	3	5	925	.201	$\frac{3}{4}$	.514
1	5	$5\frac{1}{2}$	925	.277	1	.688
1	8	5	925	.913	4	.694
1	12	6	925	1.71	5	.720
3	5	29	925	.478	$\frac{1}{2}$	1.072
3	6	30	990	.504	$\frac{1}{2}$	.665
5	8	59	860	.742	1	1.088
5	9	65	905	.995	1	1.090
6	6	81	840	2.72	5	1.334
6	7	93	990	3.56	5	1.000

compound in which they exist in the clay and on the temperature. Some silicates seem to resist attack. This may eliminate large amounts of iron, calcium, magnesium, and the alkalis from the possibility of absorbing sulphur. Other silicates yield more sulphates the longer they are exposed to sulphur gases and the stronger the gases. Carbonates existing in the free state are easily attacked by sulphur gases. Trioxide with water vapor and not gaseous sulphur dioxide, however, is the attacking agent. The intensity of the attack therefore increases around 800°F, when kaolinite gives off water of constitution. The attack ceases and the sulphates begin to decompose about 1000°F.

When pyrite oxidizes in such a clay there is evidence of a direct interchange of bases when the temperature is in the neighborhood of 1000°F. Iron sulphate seems to decompose a little below calcium sulphate, and this, in an atmosphere occasionally reducing, a little below magnesium sulphate. Under such circumstances a reaction such as:

$$Fe_2(SO_4)_3 + 3CaCO_3 = Fe_2O_3 + 3CaSO_4 + 3CO_2$$

can take place. It is also possible for pyrite to begin oxidizing to form various sulphates and then carbonaceous matter in the clay to burn and reduce the iron sulphate to sulphide without appreciably affecting the other sulphates.

TABLE X

UPPER FREEPORT CLAY FIRED IN VARIOUS KILNS TO VARIOUS TEMPERATURES

Table no.	Test no.	Time fired hrs.	Temp. °F	Grams S 2 sq.in. floor	Fuel equiv. atm. per cent	Per cent SO_3
1	1	4	770	.170	1	.452
1	7	3¾	770	.99	5	.550
3	3	27	775	.416	½	1.012
6	5	69	770	2.42	5	1.092
1	3	7	1075	.674	1	.386
1	6	5½	1075	1.30	4	.698
1	10	5	1075	1.88	5	.394
3	7	31	1075	.548	½	.460
6	8	105	1200 est.	4.52	5	.886
3	8	45	1545	.944	½	.154
5	11	77	1575	1.56	1	.084
6	9	117	1545	5.60	5	.174
3	9	52	1760	1.17	½	.114
5	12	83	1760	1.87	1	.086
6	12	153	1740	8.48	5	.066
6	13	165	1740	9.28	5	.110

There is little possibility of reducing scumming by changing from a fuel containing much sulphur to one containing only a little. Com-

parative tests with a clay rich in bases show that, under excellent firing conditions almost as much sulphate was formed as under heavy sulphur exposure. Even under these excellent conditions there was twelve times as much sulphur furnished per unit area as there was absorbed in the surface layer one quarter inch deep. Aside from proper drying and firing the prevention of scumming lies in the selection of clays free from scum-forming bases, iron, calcium, and magnesium carbonates.

Water vapor is the only intermediate agent needed for the formation of scum or efflorescence from its constituents in a kiln. It is necessary since the action of a gas on a solid is slight. Reduction of the water vapor in the kiln by thorough drying of the ware and a good draft during water-smoking is the surest method of avoiding trouble and saving time and fuel.

Conclusions

The calculations and results of experiments presented in this paper bring out the following facts, some of which are somewhat at variance with present ideas:

1. Even under extreme conditions of exposure to sulphur gases in the kiln atmosphere, only a small proportion of the bases present in the clay that was studied (iron, alumina, lime, magnesia, and potash) were converted to sulphates.

2. The greatest amount of sulphur absorbed by the ware was at about 925°F.

3. When heated to 925°F in various commercial kilns the ware absorbed little more sulphur from the gases of a coal containing 5% than from one containing ½%S.

4. Under the above conditions the ware absorbed little more sulphur when the ware was fired in 87 hours than when it was fired in 29 hours.

5. Calculations showed that when firing with a coal containing ½%S to 925°F in 29 hours, less than 8% of the sulphur gases which passed over a given surface of ware was absorbed. At the opposite extreme when the coal contained 5%S and 925°F was attained in 87 hours a much lower percentage of the sulphur gases was absorbed and the actual amount absorbed was but little more than in the other case.

6. At higher temperatures the decomposition of sulphates was nearly the same function of temperature in all of the commercial kilns studied. The effect of the Mass Law in impeding the decomposition of sulphates was unnoticeable, due to the low concentration of sulphur gases in the kiln under any circumstances.

7. A reason for this was shown by calculations as follows: A 5% volatile sulphur coal on burning in 100% excess air makes only 1% SO_2 in the kiln atmosphere. Only a fraction of this is converted to SO_3 by catalysis. An entire kiln charge of bricks made from this clay at the time when the sulphates are decomposing most rapidly would evolve SO_3 at the rate of only 2.6% of the volume of gases passing through the kiln. Therefore the dilution of the sulphur gases is so great that the effect of the Law of Mass action is unnoticeable.

This work was carried out from the point of view of the heavy clay products manufacturer only. The conclusions may not be applicable to ware carrying a glaze or one in which a glass bond is developed.

The above method of study is recommended to anyone wishing to determine exactly what is happening to the ware in a kiln. Coupled with a well chosen series of experimental firings, it will serve as a guide to show just where and how much the firing schedule can be shortened. This will lead to the greatest possible saving in fuel, labor and overhead and the maximum output from equipment at hand.

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Abrasives

Grinding wheel speeds on commutators. ANON. *Power*, **62** [26], 1009 (1925).—The best peripheral speeds for grinding wheels grinding commutators are given. C. J. H.

Characteristics and uses of ground gears. H. F. JARCUTT. *Mech. Eng.*, **48**, 1 (1926).—The two outstanding charac. of ground gears are extreme accuracy and the possibility of making a straight-toothed gear of mat. with any desirable properties. Accurate gears eliminate objectionable noises in automobile gearing. Interesting figures are given showing the accuracy of ground gears and conditions affecting their life. C. J. H.

Centerless grinding discussed. W. W. SEABURY. *Abrasive Ind.*, **7**, 1 (1926).—This is a discussion of a "Theory and Practice of Centerless Grinding" by W. J. PEETS in *Mech. Eng.* Various methods of centerless grinding used at the shops of the Ford Motor Co. are illustrated. C. J. H.

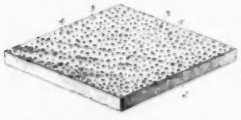
Analyze grinding wheel action. ALAN A. WOOD. *Abrasive Ind.*, **6** [12], 376 (1925).—The theory of grinding is explained. Comparisons are made of grinding chips and lathe turnings. Pictures, diagrams and curves are given. C. J. H.

Carborundum. ANON. *The Engineer* (London), **140**, 608 (1925).—Discussion of history, manuf., and chem. reactions involved. Carborundum, SiC, is formed by reaction between sand and coke at 1840°C. At 2240°C, SiC decomposes into volatile silicon and carbon as graphite. E. E. P.

Structure of carborundum (SiC). H. OTT. *Z. Krist.*, **61**, 515–31 (1925); cf. *C. A.*, **19**, 212, 3393.—Carborundum (type II) can be considered as having a zinc blende structure twinned along a trigonal axis. The compd. is non-polar. (*C. A.*)

PATENTS

Method of making articles of ceramic bonded granular material. MILTON F. BEECHER and MACDONALD C. BOOZE. U. S. 1,567,020, Dec. 22, 1925. The method of making a ceram. article comprising the steps of mixing abrasive grains and a vitrifiable bond in dry condition and thereafter firing the unformed dry mixt. to vitrify the bond.



Antislip tile. FRANK J. TONE. U. S. 1,567,091, Dec. 29, 1925. As a new article of manuf., a fired tile having in its tread surface clusters of abrasive grains previously bonded by a ceramic binder.

Method of manufacturing artificial abrasives. CLARENCE J. BROCKBANK. U. S. 1,568,873, Jan. 5, 1926. The method of producing cryst. alumina substantially free from impurities, which consists in fusing an aluminous ore with a reducing agent and boric acid, and sepg. the fused alumina from the reduction products.

Process for the treatment of oxidic raw materials. TURE ROBERT HAGLUND. U. S. 1,569,483, Jan. 12, 1926. The process of purifying bauxite comprising removing oxides of iron, silicon and titanium and dissolving aluminum oxide in a sulphide contg. slag by fusing the bauxite with a sulphide yielding mat. and a reducing agent and sepg. the sulphide-aluminum-oxide slag from the reduced alloy.

Art

Dynamic symmetry. MARIE GUGLE. *Bull. Amer. Ceram. Soc.*, **5** [2], 157–61 (1926). —Static symmetry has been used since the days of classic art. The dimensions of its designs are commensurable. The late Jay Hambidge of Yale Univ. rediscovered the more subtle proportion used in the classic art of Egypt and Greece. He named it dynamic symmetry. Examples of the ratios and their bases are given in considerable detail. E. J. V.

Modern ceramics of art. CARL BERGMANS. *Bull. Amer. Ceram. Soc.* **5** [2], 161–63 (1926).—The importation of ceram. ware is briefly reviewed. A rapidly developing sense of selection made possible by greater purchasing power has created a market for more artistic products. Faience tile are used to illustrate this point. The lack of craftsmen trained in art is very evident in the large factories. A plea is made for some ceram. art training in connection with ceram. engineering courses. E. J. V.

Black-figured vases—Recent accessions. GISELA M. A. RICHTER. *Bull. Met. Mus. Art*, Dec., pp. 297–301 (1925).—From the purely decorative point of view the Athenian black-figured vases are often superior to the red-figured examples. They are nearer to the 7th-century wares in time, spirit and technique, when effective design was considered more important than the content of the representation or its execution. The earliest of the new vases is a small Corinthian kotyle of the first half of the 6th century B. C., with a lion and a bird on either side, a bird beneath each handle, and still another bird underneath the foot, the background strewn with rosettes. The design is very pleasing, following closely the early traditions. Another is a deep kylix on a low foot, probably Corinthian. It is decorated with dancing men on either side and with effective palmette patterns below the handles. The provenance is said to be Taranto. Most of the pieces however, belong to the fully developed Athenian black-figured style of 2nd half of 6th and early part of 5th centuries. They represent the ware which ousted all competitors and enabled Athens to absorb the market of the world. The feeling for design is strongly evident in a series of kylixes, each a masterpiece in composition. But it was not only pure decoration which appealed to the vase designer of this period. He became more interested in depicting the daily life he saw around him and the manifold myths which constituted his history and religion. We have a fine example in a kylix with two groups of fighting warriors, rather large in scale on the inside, and sphinxes, eyes, and dolphins on the outside. Another kylix has a representation of an archer on horseback and by his side a warrior sliding down from his horse. On the outside are two heads and an inscription between two lions, repeated on both sides. This is the only surviving specimen of Epitimos' work. The potter had a right to be proud of it and to attach his signature; for, with its high, well-proportioned foot and its wide deep bowl it is a fine achievement. It is not a new find, being mentioned in 1829 in Canino's Museum étrusque No. 2309, as coming from Vulci, and is listed by Klein and Hoppin. The Iliad and the Odyssey formed, so to speak, the bible of the classical Greeks. Every child was brought up on them and, naturally, Homeric legends were depicted by the vase painters. Sometimes the execution was not particularly careful, but the story was told simply and directly, conveying the desired effect. A magnificent column krater nearly 20 inches high, has as its chief picture a gigantomachy; Athena and Ares battling against giants with a four-horse chariot standing by. The confusion of the battlefield is admirably conveyed. On

the other side is a peaceful scene of Dionysos surrounded by dancing satyrs and maenads; and on the rim are animals and sphinxes. A large loutrophoros is an important accession; for such vases, especially of black-figured period, are distinctly rare and ours is an unusually complete example. Vases of this shape were used by Athenian maidens for bringing the water of the bridal bath from the spring Kallirrhoe, and they were also placed on the tomb of a maiden or youth who died unmarried. Our vase represents a dead youth lying in state, surrounded by mourners, while below is a cavalcade of horsemen—the funeral procession. Now and then the Athenian potter varied his effect and painted his figures on a white engobe instead of directly on the red clay. Three among these new pieces show this technique. On one of these is a scene of men climbing a fruit tree and being surprised by a large serpent. It is an interesting example of early "landscape" in two dimensions only, with the emphasis largely on its decorative effect. It is interesting to compare these Athenian examples with a contemporary Etrusco-Ionian amphora. The technique is the same, black figures on a red ground with incisions for details and purple and white as accessory colors, but the spirit is quite different. There is a gaiety and extravagant exuberance foreign to the restrained Attic representation. Technically the work is rather careless. The black glaze is poor in quality and has been allowed to run over the circular bands. A. A. A.

Ceramic art and the ceramic artist. EDMUND DEF. CURTIS. *The Ceramist*, **7** [1], 41–43 (1925).—C. states that the gulf between indus. and art is due largely to the fact that there is no provision made in undergraduate work for the training of the real ceramic artists. A ceram. artist should be a practical potter. A. E. R. W.

Cement, Lime and Plaster

High strength Portland cement in Germany. OSCAR HURT. *Rev. Mat. Constr. Trav. Pub.*, **191**, 197–201 (1925).—High strength cement on a commercial scale was first made in 1913 at the cement factory of Vorarlberg at Lorüns, and was extensively used during the war. Only after a precarious existence in the last few years has it found favor for extended use. H. has obtained samples and tested them, the phys. results being given in Table I, and some chem. anal. in Table II. It is evident from the anal. that the cements are similar to ordinary Port. cements, and the characteristic difference is noted in the fineness of the high strength cement as compared with a residue of about 15 % on 4900-mesh per sq. cm. for ordinary Port. The high strength cements attain a strength of about 250 kg. per sq. cm. in three days, a value only reached by ordinary German Port. cement in 28 days, clearly indicating their initial high strength. In discussing the necessary steps to be taken in reproducing such cements, H. shows the effect on the strength by simply grinding finer the ordinary product, Table III.

TABLE I

Sample	Fineness		Water %	Set hrs.		Compressive and tensile strength maintained in water					
High Strength Cements	4900	900	normal	Ini-	Final	3 days		7 days		28 days	
			consist.	tial		C.	T.	C.	T.	C.	T.
"Allemannia," Höver, near Hanover	6.0	0.2	27.0	3.5	7.0	312	28.8	423	32.3	545	39.0
"Dickerhoff Doppel," Biebrich on Rhine	4.4	0.4	25.6	3.0	7.0	320	27.0	424	29.8	538	37.5
"Bärenstark," Rüdersdorf, near Berlin	1.6	tr.	26.0	2.0	5.0	243	27.0	338	25.7	428	32.9
Bauxitlandzement											
A	7.4	0.4	26.0	4.0	11.0	253	24.3	342	22.5	379	23.5
B	1.7	0.1	26.5	3.8	7.3	299	30.2	419	34.0	502	35.6

TABLE II

	High Strength Cements		Bauxitlandzement	
	"Dickerhoff Doppel" %	"Bärenstark"	A	B
SiO_2	21.20	20.10	16.96	18.62
Al_2O_3	5.03	3.61	8.17	7.58
Fe_2O_3	4.33	5.90	6.05	5.76
CaO	63.60	64.60	64.58	62.46
MgO	2.11	2.68	1.61	1.78
SO_3	0.84	2.70	1.52	1.81
Ignition loss	2.00	0.40	0.44	1.93
Silica modulus	2.28	2.12	1.19	1.40
Hydraulic modulus	2.08	2.18	2.07	1.95

TABLE III

	Residue on screens			Compressive strength maintained in water			
Port. cement	900	4900	10,000	2d.	3d.	7d.	28d.
Commercial	1.2	18.4	25.6	136	184	188	432
Ground finer	0.6	13.0	21.0	152	200	320	—
Ground finer	0.2	8.0	15.6	192	260	332	464
Ground finer	0.2	4.6	9.4	200	320	350	520
Ground finer	0.0	0.5	3.5	320	360	480	—

Another cement manufactured in Germany is "Bauxitlandzement" made with small additions of Hessian bauxite, its properties being given in Tables I and II. High grade fused cement is now also being made in Germany. L. N.

Relation between water permeability and water absorption of concrete. EVALD ANDERSON. *Ind. Eng. Chem.*, **18** [1], 17 (1926).—Water absorption and water permeability tests for concrete are reported. They show no direct relation between porosity and water-tightness. A discussion of the reason for this follows. F. G. J.

The rate of solution and availability of commercial limes. HASLAM, ADAMS and KEAN. *Ind. Eng. Chem.*, **18** [1], 19 (1926).—The availability of a commercial lime in general depends on the rate of soln. The rate of soln. depends on the fineness of the lime and is directly proportional to the area and to the ultimate soly. of the lime. Expts. were conducted on the effects of the presence of various acids and salts forming sol. and insol. lime compds. These show conclusively that for an availability test for lime to be of any great value the test must be based on the particular process in which the lime is to be used. F. G. J.

Permeability of concrete. H. C. TOY. *Inst. Civ. Eng.*, **20** (1924); *Jour. Soc. Chem. Ind.*, **44B**, 960 (1925).—Permeability, or the flow of water through concrete, must be distinguished from porosity, which is detd. by per cent of voids. Assuming the flow of water through capillary veins in concrete to be analogous to flow through a tube, permeability $= Sxpa^2/8m^2\ t^{2n-1}\ N$, where S is area of surface in contact with water, X,% voids in concrete, p, pressure difference causing flow, a, radius of capillaries in concrete, t, thickness of concrete, N, coeff. of viscosity. The deductions drawn from this formula are confirmed by expt. The compn. of the sand is the detg. factor in the permeability of concrete; fine sand gives high permeability. Permeability decreases more rapidly than cement content increases, as both total vol. and size of voids are affected. H. H. S.

Close water control important in alumina cement concrete. P. H. BATES. *Eng. News Rec.*, **95,** 462–3 (1925).—Expts. showed that marked decrease in strength accompanies use of excess water with high-alumina cement, as little as 0.5% (of wt. of dry mix) causing distinct reduction. Grading of aggregate, by influencing amt. of water required to secure workability, is also a factor. (*C. A.*)

The properties of aluminate cement. R. L. MORRISON. *Cont. Rec.*, **39,** 417–8 (1925). —Tests of properties of American aluminate cement (Atlas Lumnite Cement Co.) indicated that max. strength is reached in 3–5 days, strength of 1:2:4 aluminate cement concrete at 5 days being almost twice that of the best 1:2:4 Portland cement concrete at 29 days. At 29 days a 1:4:8 aluminate cement concrete has approx. the same strength as 1:3:6 Portland cement concrete, while 1:3:6 aluminate is approx. as strong as 1:2:4 Portland. In practically all the cases, the strength of aluminate concrete was inversely proportional to the amt. of water used. The amt. of water required to produce a given slump with aluminate cement was practically the same as with Portland cement. In almost every case cylinders cured in dry air were stronger than those cured in moist air, the av. difference in strength being 7%. An av. of 209 lbs. per sq. in. was required to break at the end of 24 hrs., 6 cylinders made by replacing in molds half-briquets of Portland cement and filling the rest of the space with aluminate cement mortar. Results of setting time tests made upon mixts. of aluminate and Portland cements showed that flash set does not occur unless the proportion of Portland cement falls between 33 and 90%. (*C. A.*)

The influence of the quantity of water in the mixture on the heat of setting of eluminous cements. J. BERTET. *Genie civil*, **84,** 542–4 (1925).—Two distinct reactions are indicated. (*C. A.*)

Slag in wet process cement manufacture. SOZO KANOH. *Concrete* (Mill Section) **27,** 93–7 (1925).—Data are given on setting time of clay-limestone and slag-limestone slurries. Because of hydraulic properties of granulated slag, continuous agitation of slag-limestone slurry is necessary. (*C. A.*)

Artificial magnesia from dolomite. G. D. *Rev. chim. ind.*, **34,** 278–81 (1925).—Brief outline of some of the more important processes proposed for production of practically CaO-free MgO. (*C. A.*)

PATENT

Cements. L. G. PATROUILLEAU AND ALUMINE ET DERIVES. Brit. 232,988, Dec. 19, 1924. In making aluminous cements the raw mats. are treated with SO_2 or a substance capable of supplying SO_2 in order to prevent formation of silicates. H_2S, S, sulphides such as Fe pyrites, sulphites, hyposulphites, or sulphates such as those of Fe, or Al, Ca may be used.

Enamel

Practical considerations regarding enameling furnaces. W. A. DARRAH. *Bull. Amer. Ceram. Soc.*, **5** [2], 145–57 (1926).—A short review of the development of enameling is given. The salient points of enamels and enameling are very generally discussed. The prime objectives of commercial enameling are high quality and economy. Heat requirements for successful enameling are enumerated and discussed. Various types of enameling fur. are described, pointing out the advantages and limitations in the use of each. Some desirable fur. charac. and fuel requirements are discussed. E. J. V.

Tables for calculating the melted weight and coefficient of expansion of enamels. A. MALINOVSZKY. *The Ceramist*, **7** [1], 23–38 (1925).—M. gives tables and shows how

they can be used for simplifying the calcn. of melted weights and coeffs. of expansion of enamels as well as the constituents in a feldpsar and in melted borax. The simplification results in a saving in time and a gain in accuracy. A. E. R. W.

Free quartz in feldspar. (A Discussion). H. D. PANTON, F. P. KNIGHT, JR., A. MALINOVSZKY and HOMER F. STALEY. *Ceramist*, **7** [2], 81–93 (1925).—(1) P. states the assumptions made when the Watkins' formula is used for calcg. free quartz from the chem. anal. and gives a more exact method which does not involve this assumption. (2) K. points out errors in a quotation in a previous paper by M. and also errors in the Watkins' method. K. states there is no acceptable way to calc. free quartz content from an anal. of a feldspar except by norms. K. compares the results of calcns. based on the mol. numbers as given in Dr. Washington's tables with those given by M. in a previous paper. (3) M. defends the methods and calcns., given in his paper, as being of practical use and says that his experience shows that the calcn. of the coeff. of expansion of a feldspar by Staley's method is much more important than the calcn. of the free quartz. (4) S. states there is no "Watkins' Method" for calcg. free quartz and states that the other methods given by P., K., and M. are essentially the same. S. agrees with M. as to the greater importance of calcns. of the coeff. of expansion. A. E. R. W.

Fishscaling of sheet iron enamels. ANON. *Ceram. Ind.*, **6** [1], 40–44 (1926).—The article contains the opinions of seven prominent enamel men on the causes and prevention of fishscaling. The chief causes advanced are: (1) compn. of the enamel, (2) improper smelting, (3) improper milling, (4) character of the clay used, (5) character of the iron, (6) improper pickling of the iron, (7) under-firing, (8) over-firing, (9) type of fur., and (10) leaking of muffle doors. R. E. G.

PATENTS

Vitreous compositions and articles made therefrom. EUGENE CHARLES BUCK. U. S. 1,570,202, Jan. 19, 1926. An improved vitreous composition comprising a fused complex metaphosphate of aluminum and an alkali earth metal substantially free from silica.

Baking enamels. T. E. THOMPSON. U. S. 1,558,517, Oct. 27. Powdered fused enamel is applied to automobile bodies or other articles to be coated together with a fluid vehicle such as linseed oil or varnish which leaves a binding residue, and the coated articles are then baked at a temp. below the fusion point of the enamel. (*C. A.*)

Glass

Comparative study of laboratory chemical glassware made in France, England, Germany, and Austria. P. NICOLARDOT. *Le Verre*, **5**, 49–53, 73–76, 97–104 (1925).—A résumé of work done in 1916 on Erlenmeyer flasks of 500 cc capacity. To approach the working conditions of the lab., decinormal solns. of reagents were employed. The following series of tests were made. *1st Series.* (1) Boiling 300 cc distilled water, without reflux condenser for three hrs. on a Bunsen flame. (Test repeated three times.) (2) Effect of 300 cc cold water (room temp.) standing in the vessel for a week. (3) Boiling for three hrs. without reflux condenser with 300 cc solns. of (*a*) n/10 HCl, (*b*) 50% NH_3 soln. (*c*) n/10 NH_4Cl, (*d*) n/10 Na_2CO_3. *2nd Series.* Htg. the flasks in an autoclave for three hrs. at 120°, 140° and 160° C with const. htg. and cooling conditions. *3rd Series.* After the surfaces of the flasks had been removed by the action of water and water vapor (in the autoclave) the tests with water, HCl and Na_2CO_3 were repeated to compare the rates of loss of new and used flasks. The losses in wt. were detd. directly by weighing the flasks and were controlled by weighing the residues calcined at low temps. Qual. anal. of all the residues were made, and in all cases all the elements of the respective glasses were found

	Series I					Loss in milligrams		
	Boiling water			Cold water	HCl n/10	NH_3 50%	NH_4Cl n/10	Na_2CO_3 n/10
	1	2	3	1 week				
German								
Jena	4.0	3.0	2.5	nil	0.5	4.0	4.5	14.0
Thuringian								
R.	5.0	1.5	1.0	0.5	5.0	5.0	2.0	27.0
no mark	10.0	6.0	5.0	1.5	1.5	6.0	3.5	37.0
Ehrenfeld	1.5	0.5	nil	nil	nil	5.5	5.5	24.0
Austro-Hungarian								
Krasna	8.0	6.0	11.0	1.0	0.5	12.5	8.0	22.0
Kavalier	6.0	6.0	7.0	0.5	0.5	8.0	7.0	103.0
Zsolna	5.5	3.5	3.0	nil	nil	11.5	5.5	151.0
Bohemian (no mark)	8.0	13.0	11.0	nil	nil	24.0	20.0	145.0
French								
France	5.5	3.5	3.5	nil	0.5	10.0	5.5	20.5
Airaine	3.0	2.5	2.5	nil	0.5	6.5	7.0	51.0
Labo 1	2.0	0.5	0.5	0.5	0.5	8.5	5.0	27.0
Labo 2	1.5	1.0	0.5	nil	nil	10.0	2.5	26.0
Fina	7.5	8.5	8.0	0.5	nil	8.0	4.0	33.0
Neutra	2.0	1.0	0.5	nil	nil	3.0	2.0	35.0
Refract	2.0	1.5	1.0	nil	nil	4.0	2.0	46.0
English	2.0	1.0	0.5	nil	2.0	5.5	2.0	38.0

	Series II			Series III		
					HCl	Na_2CO_3
	100°	140°	160°	Water	n/10	n/10
Jena	4.0	9.0	31.0	nil	6.0	27.0
Thuringian R	8.0	3.5	77.0	4.5	2.0	24.0
no mark	25.0	49.0	84.0	12.0	14.0	35.0
Ehrenfeld	2.0	2.5	14.0	1.0	2.0	27.0
Krasna	16.0	72.0	99.0	6.0	1.0	74.0
Kavalier	20.0	74.0	126.0	2.0	2.0	96.0
Zsolna	15.0	59.0	96.0	6.0	2.0	158.0
France	5.0	8.0	75.1	1.0	2.0	20.0
Airaine	13.5	42.0	71.0	14.0	0:5	155.0
Labo 1	nil	9.0	37.0	nil	0.5	31.0
Labo 2	5.0	6.0	67.0	0.5	nil	32.0
Fina	21.0	60.0	86.0	12.0	8.0	66.0
Neutra	2.0	9.0	35.0	0.5	nil	34.0
Refract	2.0	6.0	24.0	0.5	nil	38.0
English	4.0	5.0	14.0	1.0	4.0	33.0
Bohemian n.m.	69.0	163.0	200.0			

Classification of chem. glasses. The losses sustanied by each glass in every test were then totalled for each series of tests and the glasses were listed in the order of their losses.

Losses in Milligrams

Series I		Series II		Series III		Grand Total	
Jena	30.5	Ehrenfeld	18.5	France	23	(1) Ehrenfeld	83.5
Thuringian R	32	English	23	Ehrenfeld	30	(2) Jena	107.5
Ehrenfeld	35	Refract	42	Thurginian R	30.5	(3) English	121
Labo	42	Jena	44	Labo	32	(4) Neutra	124
Neutra	43.5	Neutra	46	Jena	33	(5) Labo 1	26
France	49	Labo	52	Neutra	34.5	(6) Refract	137
English	51	France	88.1	English	37	(7) Thur. R.	151
Thur. n.m.	55	Thuringian R.	88.5	Refract	38.5	(8) France	160.1
Refract	56.5	Airaine	126.5	Thur. n.m.	61	(9) Thur. n.m.	274
Fina	69	Thur. n.m.	158	Krasna	81	(10) Fina	317
Airaine	73.5	Fina	162	Fina	86	(11) Airaine	369.5
Kavalier	137.5	Zsolna	171	Kavalier	100	(12) Krasna	436
Krasna	168.0	Krasna	187	Zsolna	166	(13) Kavalier	457.5
Zsolna	180	Kavalier	220	Airaine	169.5	(14) Zsolna	517
Boh. n.m.	211.5	Boh. n.m.	>450	Boh. n.m.	large	(15) Boh. n.m.	>800

If 140 mg. is fixed as the max. loss for all 14 tests for the best glasses, and 280 mg. for the average glasses, the following subdivisions may be made:

1. High resistant glasses. Ehrenfeld, Jena, English, Neutra, Labo and Refract.
2. Glasses of moderate resist. Thuringian R., France and Thuringian n.m.
3. Glasses of low resist. Fina, Airaine, Krasna, Kavalier, Zsolna and Bohemian n.m. It is to be noted that the classification obtained by the autoclave tests is very close to that detd. by the aggregate tests.

Chemical Analyses

	SiO_2	B_2O_3	Al_2O_3	PbO	CaO	ZnO	MgO	Na_2O	K_2O
1. Ehrenfeld	66.54	5.53	3.82	nil	1.25	8.98	2.56	6.94	4.02
2. Jena	66.04	5.92	1.05	nil	nil	10.02	5.98	10.20	tr.
3. English	63.52	8.62	9.46	nil	tr.	7.48	tr.	10.94	tr.
4. Neutra	67.58	1.50	8.68	nil	6.27	nil	0.86	15.03	tr.
5. Labo	67.52	4.98	0.54	nil	5.60	6.02	0.06	6.51	8.52
6. Refract	76.50	7.56	4.98	nil	0.28	nil	0.12	10.10	nil
7. Thuringian R	67.84	6.32	1.98	nil	2.01	5.42	4.07	11.11	0.9
8. France	71.92	nil	0.41	nil	6.86	5.96	0.28	14.20	nil
9. Thuringian n.m.	68.92	0.98	2.02	nil	7.49	nil	0.06	17.20	2.91
10. Fina	70.22	nil	1.48	nil	9.29	nil	0.17	18.64	nil
11. Airaine	70.10	nil	0.41	4.94	6.27	nil	0.36	11.23	5.64
12. Krasna	72.92	1.96	0.32	nil	8.17	nil	0.28	13.89	2.27
13. Kavalier	71.60	3.94	0.50	nil	8.56	nil	0.26	9.43	5.54
14. Zsolna	75.02	1.50	0.20	nil	8.51	nil	tr.	8.84	5.96

Molecular Formulas (with $RO+R_2O$ equivalent to 1)

	SiO_2	B_2O_3	Al_2O_3	PbO	CaO	ZnO	MgO	Na_2O	K_2O
1. Ehrenfeld	3.12	0.22	0.10		0.06	0.31	0.18	0.33	0.12
2. Jena	1.95	0.14	0.18			0.44	0.27	0.29	
3. English	3.92	0.46	0.34			0.35		0.65	
4. Neutra	2.95	0.06	0.23		0.30		0.06	0.64	
5. Labo	3.03	0.19	0.02		0.27	0.20		0.28	0.25
6. Refract	7.65	0.66	0.29				0.02	0.98	

	SiO_2	B_2O_3	Al_2O_3	PbO	CaO	ZnO	MgO	Na_2O	K_2O
7. Thuringian R	2.87	0.23	0.05		0.10	0.17	0.25	0.45	0.03
8. France	2.77		0.01		0.28	0.17	0.02	0.53	
9. Thuringian n.m.	2.57	0.03	0.04		0.30			0.63	0.07
10. Fina	2.49		0.03		0.35			0.65	
11. Airaine	2.46		0.01	0.03	0.24		0.03	0.38	0.13
12. Krasna	3.06	0.07	0.01		0.36		0.02	0.56	0.06
13. Kavalier	3.20	0.15	0.01		0.41		0.02	0.41	0.16
14. Zsolna	3.47	0.06	0.06		0.43		0.02	0.40	0.17

Interpretation of results. The proportion of lime is small in the high resistant glasses, whereas the alumina content is apparently high in these glasses. Those contg. the highest and lowest silica mol. ratio are among the most resistant glasses. The most resistant glasses contain boric anhydride and alumina in fair quantities, but the best of them do not contain high boric anhydride content. In all cases it seems preferable to replace part of the soda by zinc oxide or by magnesia. The glasses of lowest chem. resist., some of which contain boric anhydride, contain no alumina; they are also rich in lime and potash, poor in magnesia and contain no zinc oxide. It would appear that high lime glasses are the least resist. and that the potash glasses are less resist. than the soda glasses. From the relative proportions of bases and alkalis (to the other constituents) it is not possible to predict the resist. of a glass. *Calculation of losses per unit surface.* Due to the slightly different shapes of the flasks examined, it was found that the surface of glass exposed to 300 cc of water was sufficiently variant to warrant consideration. The amount of surface exposed to 100, 200 and 300 cc of water was detd. for each glass, and the losses reported for test series 1, 2, and 3, were recalcd. on a basis of loss in mg. per 100 sq. cm. of surface. All details are given. The grand totals in order of resist. are Jena 75.92, Ehrenfeld 79.90, Labo 82.11, Refract 82.67, English 87.38, Neutra 87.91, France 107.08, Thuringian R. 117.61, Thuringian n.m. 192.45, Zsolna 202.81, Fina 205.85, Airaine 259.75, Krasna 294.10, Kavalier 318.25. N. gives in fair detail the results obtained in recent years by Weber, Foerster, M. Walker and of Cauwood, English and Turner, giving the compns., the expts. and their conclusions with his criticisms. There are also included some preliminary and other tests not included in the three series of tests discussed above. L. N.

The eight hour day in the French glass industry. ANON. *Le Verre*, **5**, 105–106 (1925).—A copy of the complete text of the decree of Feb. 19, 1925 and effective March 5, declaring the enforcement of the 8 hr. day in the glass factories, with the exception of the plate glass factories and those employing automatic machs., for which new rulings are being drafted. The week consists of 48 hrs. which may be divided into working days of (1) 8 hrs. each, or (2) into days of unequal length with a max. of 9 hrs. per day, to permit a holiday of one half day per week. L. N.

New method of constructing large telescopic mirrors. G. W. RITCHEY. *Compt. Rend.*, **181**, 208–10 (1925).—The disks are made from circular plates and rectangular compartments composed of well-annealed glass. The sep. parts are joined by bakelite under press. and at a temp. of 140° C. A 75 cm. mirror made by this process has proved to be satisfactory. D. E. S.

The glass industry and the Leipzig autumn fair. FRIEDRICH HUTH. *Diamant.*, **47** [27], 561 (1925).—A report of the various locations of the exhibits of the many phases of the glass indus. in the bldgs. used for the annual autumn fair at Leipzig. Particularly interesting exhibits of glass are given special mention. Glass working mach. was also shown. A "Delta-Universal" and several other newly invented machs. are mentioned. E. J. V.

Cologne's thousand-year exhibit of stained glass. ANON. *Diamant*, **47** [27], 569 (1925).—Within the bounds of the unusually spectacular exhibit at Cologne, there is much stained glass shown in a very interesting way. Examples of the work of many of the old masters that can be seen there are mentioned. The influence of the different periods on the style of the art used is shown by ref. to specific examples thereof in the various churches and cathedrals. E. J. V.

The acid etching and acid polishing of glass. O. PARKERT. *Diamant*, **47** [27], 566 (1925).—P. gives a very good detailed description of several old methods for etching glass, using the vapors of hydrofluoric acid or baths of different fluorides treated with sulphuric acid as the etching mediums. He points out disadvantages encountered in using these methods. The newer method of using a soln. consisting of equal parts of commercial hydrofluoric acid and water is discussed, as also is the polishing to a matt surface with it as the etching medium. Use of a bath of two parts sulphuric acid and one part hydrofluoric acid for producing line etchings on shapes such as vases, etc., is taken up to some extent. E. J. V.

The German glass instrument industry. ANON. *Diamant*, **47** [28], 585 (1925).—An important factor in the economic life of Germany is the glass instrument industry. The workers obtain mach.-made glass tubing and rods in various lengths and sizes where they formerly had to make it by hand. This branch of the export industry is scattered over the entire country but its chief stronghold may be said to be in the vicinity of the Thuringian Forest. There is a never-ceasing striving for improved quality in the work and due to this, the industry has been improving continually. The most important phase of the industry is that covered by chem. glassware. Of nearly as great importance is the phase dealing with thermometry and hydrometry. Great strides have been made in this field. Thermometers have been made which register from −200 to 750° C. Clinical thermometers, medical glassware and glass syringes form other phases of this industry. The artificial eyes made in Lauscha are known the world over. Incandescent lamps of all sizes are made in Ilmen and other cities. The only phase of the industry which does not deal with glass tubing and rods is that of thermos bottle manuf. Principal centers of the various phases of the industry are enumerated. E. J. V.

Stained glass in the middle ages. H. HUBER. *Diamant*, **47** [28], 589 (1925).—The oldest existing examples of stained glass in the world are those in the old bishopric of Augsburg. This city was, till the late middle ages, the center of all arts in general. It is known without a doubt that the earliest Swiss stained glass work was fostered by the Holbeins of Augsburg. Examples of the work of many of the old masters are enumerated. Many fine works in this art were destroyed during the Reformation and the Renaissance, but a few remain as the oldest in existence anywhere. E. J. V.

The finishing of plate glass. F. SALOMONIS. *Diamant*, **47** [28], 597 (1925).—S. gives a very complete description of the various steps and new automatic mach. used in carrying the plate glass from the cold, roughly finished condition to that of the finished, highly polished article. E. J. V.

Correct annealing increases profits. ANON. *Ceram. Ind.*, **6** [1], 25–27 (1926).—A discussion is given of the uses and probs. connected with leers. Curves are given showing typical heat distribution and cooling treatments on various types of glass. Different types of glass must have different annealing treatment; for example: (1) glasses rich in alkali can be annealed at fairly low temps; (2) alumina was found to reduce the annealing temp. of the glass; (3) the substitution of dolomite for part or all of the limestone, facilitates annealing; (4) colored glasses are more difficult to anneal than the clear glasses; (5) crystal glass is said to require a lower temp. than flint glass; (6) glasses of complex compn. are difficult to anneal; (7) soda-lime glasses are the easiest to anneal and the

addition of coloring oxides, with no change in the basic formula, does not change the annealing temp. R. E. G.

New English glass machine claims unique equipment. ANON. *Ceram. Ind.*, **6** [1], 28–29 (1926).—The article is an illustrated description of a new bottle machine made for an English glass plant. R. E. G.

Novel booster on leer saves fuel. ANON. *Ceram. Ind.*, **6** [1], 32 (1926).—The leer at the Sneath Glass Co., Hartford City, Ind., is described. The heat in the leer is held to $\pm 10\%$ by means of an auxiliary oil burner, which is controlled by an automatic pyrometer. The leer is heated by producer gas. R. E. G.

Tank control and devitrification. H. INSLEY. *Glass Ind.*, **7** [1], 1 (1926).—A triaxial diagram of the system SiO_2 50%.CaO 50%. SiO_2 50%. Na_2O 50%. SiO_2 is the principal feature of this article. Typical soda-lime glass compns. for various purposes are shown on the diagram. The compns. of the compds. which crystallize out, thus causing devitrification, in each case, are connected by dotted lines to these various points. Devitrification can always be prevented by raising the temp. sufficiently at the place where it starts. Where this is impossible, the crystallizing temp. can be lowered by slightly changing the compn. of the batch in a direction away from the compd. which crystallizes. F. G. J.

Continuous batch feeder in successful operation on window glass tank. ANON. *Glass Ind.*, **7** [1], 4 (1926).—A device that has been in use for several years at the St. Louis plant of the Mississippi Glass Co. The cullet is mixed with the batch and both are held in a tank or hopper above the dog house. A six inch steel pipe leads from it at an angle of 60°. At the lower end is a sleeve which can be raised or lowered by a chain and counterweight. Raising the sleeve increases the flow of batch to the dog house. A heavy pull is maintained on the tank. Scum formation causes very little trouble. The life of the tank is as long as others where the pull is much less. Distribution of refining is excellent. F. G. J.

Natural gas as fuel in glass furnace stack. J. P. SCHELLHAUS, JR. AND G. J. O'NEILL. *Glass Ind.*, **7** [1], 5 (1926).—A 44-year old 12-pot stack has been remodelled to heat with natural gas instead of coal. A single No. 6 Maxon Premix burner is used with 6 in. gas-air mixt. outlet. At 40 pots of 2200 lbs. each a week, the present rate, 8.6 cu. ft. of gas is burned per pound of glass melted. F. G. J.

Progress in glass etching. ANON. *Glass Ind.*, **7** [1], 7 (1926).—Translated from *Allgemeine Glas- und Keram-industrie*, **16**, 5. A detailed description of modern etching processes. F. G. J.

Fourcault process success at Scohy Sheet Glass Co. EDWIN P. ARTHUR. *Glass Worker*, **45** [14], 15 (1926).—The Scohy Sheet Glass Co. of Sistersville, W. Va., has had a unit of one melting tank and four Fourcault machs. in opern. since last August. They are producing a very superior grade of glass. The fuel consumption is heavy. F. G. J.

"Feuerfest" in the glass industry. LUDWIG SPRINGER. *Feuerfest*, **1** [9], 89 (1925).—The majority of all glass failures are the result of too low fur. temps. for which the low refrac. nature of the glass pots and fur. linings are responsible. A correction of this condition is a problem of major importance for industry and the magazine *Feuerfest*. F. A. W.

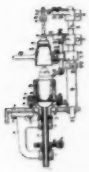
Composition and coloring of ancient glass. B. NEUMANN and G. KOTYGA. *Z. Angew. Chem.*, **38**, 776–80, 857–64 (1925); *Jour. Soc. Chem. Ind.*, **44 B**, 992 (1925).—Anal. are given of 38 samples of glass dating from 1400 B.C. to 600 A.D. They all contain less SiO_2 and more alkali than good modern glass. This was probably due to working at a lower temp., and led to soft glass of poor resist. Sulphate was present, and small bubbles give the glass a milky appearance. The stains used for coloring glass were Cu, Sn, Mn,

and Fe. Co was not found in any of the samples. A brilliant red opaque glass contained Cu and Pb. The presence of borate is not indicated in ancient glass. H. H. S.

Society of Glass Technology. ANON. *Jour. Soc. Chem. Ind.*, **44**, 1184 (1925).—At the Leeds meeting, Nov. 18th, the following papers were read: (1) "Old Yorkshire Glasshouses," by W. R. BARKER; (2) "Sillimanite bricks and kaolin-sillimanite mixtures," by H. S. HOLDSWORTH; (3) "Sillimanite pots for glass-melting," by A. COUSEN, S. ENGLISH, and W. E. S. TURNER; (4) "Shot-holing in glasshouse pots," by P. MARSON. Two papers were taken as read: "Design for glass pot-board," by F. WINKS; "Design of tank furnaces," by H. W. HOWES. H. H. S.

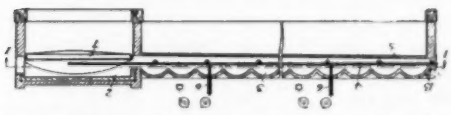
PATENTS

Method and apparatus for re-forming glass articles. HARRY A. BRIDGES AND JOHN WM. LAMPARTER. U. S. 1,566,520, Dec. 22, 1925. In a method of re-forming articles of glassware, the steps consisting in htg. the article to be re-formed to soften the same, engaging said article with a shaping surface, producing relative rotation between said article and surface, and supplying a cooling medium to said shaping surface, substantially as described.

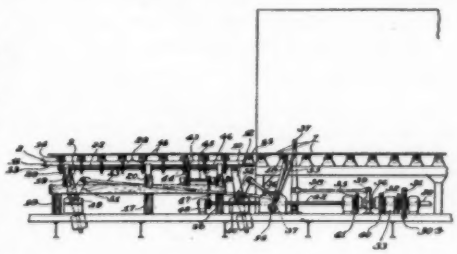


Glass bait. GEORGE G. ROBERTS. U. S. 1,567,300, Dec. 29, 1925. A bait for drawing glass in plate form consisting of a pair of separable sections pivoted together along their longitudinal edges and having a longitudinal slot between their lower meeting edges and an enlarged interior cavity extending the length of the slot, removable clamping means being employed to hold the sections together in closed relation.

Method and apparatus for flattening and annealing sheet glass. LOUIS R. SCHMERTZ. U. S. 1,567,756, Dec. 29, 1925. In the method of making flat sheet glass, the steps consisting in supplying unflattened glass to a flattening oven, flattening the glass therein, passing it from the oven through a leer to anneal and cool the glass, supplying htg. gases to the flattening oven, passing htg. gases from the flattening oven through the leer in streams above and below the glass, so regulating the relative rate of flow of the gases above and below the glass as to equalize the rate of cooling from the two faces of the glass therein, and prehtg. the unflattened glass supplied to the flattening oven to compensate for the increased temp. of the surfaces contacting with the glass in the flattening oven induced by the regulation of the gaseous flow from the flattening oven through the leer.

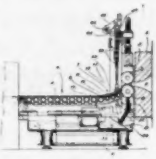


Apparatus for cracking off and handling continuously-formed sheet glass. ALBERT E. EVANS. U. S. 1,569,079, Jan. 12, 1926. App. for cracking off and handling sections of a continuously formed horizontally moving glass ribbon, transversely scored to facilitate cracking off, comprising a table for receiving and supporting a glass section mounted for vertical movement so that it may be lowered below the level of the continuously formed ribbon causing the section upon the table to crack away from the ribbon and a secondary table below the level of the first table adapted to receive the cracked

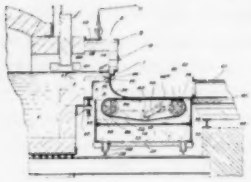


off section when the first table is lowered and provided with rolls mounted for rotation in planes at right angles to the line of movement of the ribbon.

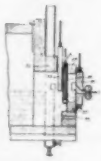
Apron for plate-glass machines. JOHN H. FOX. U. S. 1,569,082, Jan. 12, 1926. In combination with app. for continuously withdrawing a plastic sheet or ribbon of glass from a tank, including a pair of forming rolls, of a table for receiving the continuously formed sheet below the pass between the rolls, an apron intermediate the forming rolls and table mounted for swinging movement about its end adjacent the table, and means for supporting the apron at various angles of adjustment.



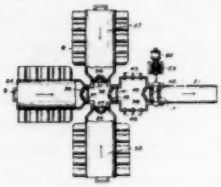
Apparatus for making sheet glass. HALBERT K. HITCHCOCK. U. S. 1,569,086, Jan. 12, 1926. In app. for forming sheet glass, a glass container adapted to carry a bath of molten glass and having a downwardly directed outlet slot through which a continuous sheet or ribbon is adapted to discharge by gravity, a laterally extending endless belt of woven fabric in position to receive the ribbon, and a cooling bath through which the belt is passed.



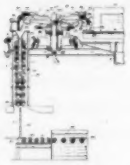
Gate for glass tanks. WILLIAM OWEN. U. S. 1,569,134, Jan. 12, 1926. The combination with a mtg. tank having an outlet opening at its forward end, of a water cooled metal gate to the rear of such outlet opening mounted for vertical movement through the top of the tank, and adapted when lowered to cut off the flow of glass to said outlet, and a vertically movable shield of refrac. mat. to the rear of the gate adapted to be lowered to a position with its lower edge adjacent to the surface of the glass bath or to be lowered into the glass and form an emergency cut off or gate.



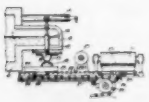
Glass tank construction. THOMAS H. SWARTZLANDER. U. S. 1,569,152, Jan. 12, 1926. In combination in a glass tank construction, a receiving chamber having a plurality of laterally opening sides with a discharge outlet at one of said sides, a plurality of mtg. tanks leading into the other sides of the tank at angles to each other of less than 180°, means for htg. the mtg. tanks, and means for heating the receiving chamber.



Sheet-glass apparatus. JOHN L. DRAKE. U. S. 1,569,465, Jan. 12, 1926. In sheet glass app., a tank contg. a mass of molten glass, means for picking up a charge of glass, and means for reducing the charge of glass through successive stages to sheet form.

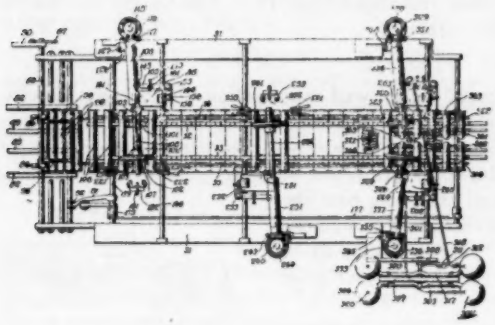


Sheet-glass-rolling apparatus. JOHN L. DRAKE. U. S. 1,569,466, Jan. 12, 1926. In sheet glass app., a tank contg. a mass of molten glass, means to discharge a gob of glass thereform, and means to reduce the gob to sheet form by rolling it along different axes.



Sheet-glass-drawing apparatus. ARTHUR E. FOWLE. U. S. 1,569,471, Jan. 12, 1926. In an app. for producing sheet glass, wherein a sheet is drawn upward from a mass of molten glass, a pot contg. the bath of molten glass, said pot having projections extending inwardly from the side walls adjacent the sources of the sheet edges, and cooling means within the pot walls and out of contact with the molten glass for maintaining the projections at a lower temp. than the other portions of the pot.

Glass-body-forming machine. HANS N. HALVERSEN. U. S. 1,569,652, Jan. 12, 1926. In a mach. of the character described, the combination of means to heat a part only of a hollow glass body, and mech. means to subject the interior of said body to a plurality of fluid press. of progressively greater intensity to round out such heated part.



Variegated glass. I. H. FREESE. U.S. 1, 529,947, March 17,1925. Streams of molten glass of different colors are united by enveloping one of the streams within the other, the glass being then molded into marbles or other articles. (*C.A.*)

Etching glass. C. C. MINTER. U. S. 1,556,796, Oct. 13. Na_2CO_3 or other alkali carbonate is heated to at least its fusion point and then brought into contact with a glass surface to be etched. (*C.A.*)

Reinforced glass sheets. G. B. RILEY. U. S. 1,560,321, Nov. 3. Glass sheets to be cemented to opposite sides of a sheet of celluloid are preliminarily treated with a soln. of "isinglass" and dextrin gum. The sheet of celluloid is treated with a soln. of colophony and castor oil and the glass and celluloid are united under the action of heat and press. (*C.A.*)

Glass-melting furnace. W. A. YUNG. U. S. 1,561,393, Nov. 10. (*C.A.*)

Heavy Clay Products

Elimination of limestone from clay. ROY A. HORNING. *Jour. Amer. Ceram. Soc.*, 9 [2], 110–13 (1926).—The method used to eliminate stones from clay at Lancaster, Pa. is given in detail. It consists of (1) careful digging of the clay, (2) working it thoroughly through a grid into the feeder, the grid holding back the larger stones, (3) feeding the clay and smaller stones into a pair of conical rolls, one of which is threaded and throws out all stones larger than 1 in., the smaller ones being crushed to a size from dust to that of a large pea, (4) thoroughly mixing all the clay, (5) regrinding through a $\frac{1}{16}$-in. opening all mat. going into brick, (6) repugging the finely ground clay and stone dust to get uniform distribution. While this adds expense of power and overhead, it produces an improved quality of ware and losses are greatly reduced. More brick are now being sold at a better price with a direct saving of 50 cents per M in cost of manuf. E. J. V.

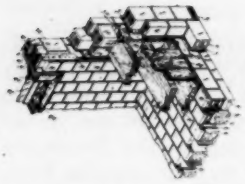
Testing thinner paving brick. ANON. *Brick and Clay Rec.*, **67** [13], 939–42 (1925).—A description is given of the tests being made under actual traffic conditions, at Arlington Experimental Farm, by the Bureau of Public Roads, in coöperation with the National Paving Brick Mfrs. Assn. R. E. G.

The effect on the principal building materials of carbonated and iron-bearing mineral waters. P. LIEGEOIS. *Ann. Soc. Geol. Belg.*, **48B**, 30–2 (1925).—Marble is diminished $\frac{1}{3}$ the original weight after 10 months immersion. Siliceous-aluminous substances are not appreciably affected, although artificial substances of like character, such as brick, are easily corroded. A mixt. of 50% sand and 50% Port. cement is completely disintegrated 4 hours after setting. Siliceous substances such as quartzite, and sandstone, and eruptive rocks with a siliceous base are not affected. (*C.A.*)

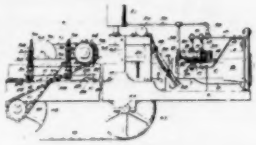
BOOK

Sampling and Testing of Highway Materials. BARTON, WM. H. and DOANE, LOUIS H. New York and London: McGraw-Hill Book Co., Inc. Cloth: 355 pp. $3.50. Reviewed in *Eng. News Rec.* **95**, 480 (1925). (*C. A.*)

PATENTS

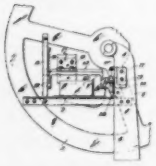


Fireproof hollow wall construction. FREDERICK HEATH. U. S. 1,568,155, Jan. 5, 1926. In a fireproof bldg. structure, the combination of a main load bearing wall consisting of hollow tile, floors within the structure, and a fireproof lining for the wall extending past the floors and extending around the normally exposed portions of the wall at window and door openings.

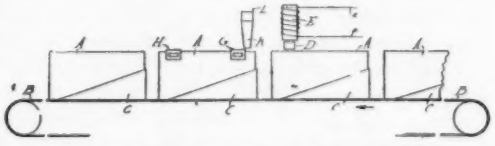


Apparatus for and method of ornamenting surfaces of ceramic products. DOUGLAS F. STEVENS. U. S. 1,570,594, Jan. 19, 1926. In a mach. arranged to have a column of plastic mat. move therein, mech. comprising a plurality of plowing members, and means whereby said members are given reciprocatory movement across and in surface mat. of the column obliquely with respect to the direction of motion thereof.

Structural unit. DOUGLAS F. STEVENS. U. S. 1,570,595, Jan. 19, 1926. A structural unit having a face of mottled-like texture characterized by flat-surfaced nubbles of different shapes disposed in unaligned distribution throughout the face area among depressions of different shapes.



Brick machine and method of operating the same. HOWARD K. KING. U. S. 1,570,501, Jan. 19, 1926. The method of preventing distortion in the wire cutting of bars into bricks, which consists in clamping the end of the bar to its moving support during the cutting opern.



Process of glazing brick. ANDREW FISCHER, JR. U. S. 1,570,137, Jan. 19, 1926. The herein described steps in a process of glazing brick which consists in pre-heating the surface of a normally non-conducting brick to bring it into condition for conducting electricity, applying glazing mat. to the heated brick and fusing said mat. by the passage of an elec. current through the surface of the brick and the glazing mat.

Refractories

Influence of Fe_2O_3 and TiO_2 on pure clays. A. H. KUECHLER. *Jour. Amer. Ceram. Soc.*, **9** [2], 104–09 (1926).—Conclusions arrived at by several investigators on similar studies are briefly outlined. Anal. of mat. used are given, as are details of procedure. Results show that approx. 10% Fe_2O_3 added lowers the fusion temp. of kaolin and fire clay 6 and 6½ cones resp., while about 5% TiO_2 lowers the fusion temp. 2 and 3 cones resp. No eutectics were revealed by this study. The fluxing action of Fe_2O_3 and TiO_2 appears to be the same on a percentage basis. E. J. V.

Refractory lining for lime kilns. BERTHOLD BLOCK. *Feuerfest*, **1** [8], 77; **1** [11], 111 (1925). Operating temp. 1000–1200° C. Presence of strong alkali necessitates the use

of basic compn. for bricks and mortar. Catalytic action of Fe_2O_3 particles derived from FeS present in the clay brick lining acts on CO present in the gases according to equation $2CO = C + CO_2$. The CO_2 generated in the brick pores leads to spalling. This reaction takes place between 300–400° C. F. A. W.

Refractories for enamelers. L. VIELHABER. *Feuerfest*, **1** [9], 90 (1925).—Chem. action in batch fur. discussed and importance of phys. properties of refrac. stressed. Smooth surface, fine grain and low porosity important. As the joints are more vulnerable than the brick, make as thin as possible and use blocks as large as practical. Tanks in which melts contg. a minimum of fluorides and borax are made show the longest life. F. A. W.

Purification of graphite in electric furnace at very high temp. EUGEN RYSCHKEWITSCH. *Feuerfest*, **1** [10], 101–104 (1925).—In some instances graphite is required in a degree of purity unattainable by ordinary methods of prepn. Chem. purification is impractical. The diff. in temp. of dissocn. between graphite and its accompanying silicate impurities is so great that purification can be accomplished by electrothermal means. To prevent oxidation an amt. of amorphous carbon detd. by anal. is added. The process is patented in most civilized countries. F. A. W.

Note on refractories for ovens and kilns. ANON. *Fuels and Fur.*, **3**, 1343 (1925).—This is an abstract of a paper read before the Ceramic Society at London by W. EMERY. Refracs. used in the construction of intermittent ovens and kilns and in continuous ovens and kilns were dealt with. Particular attention was paid to minimizing the slagging action on the refracs. when coals contg. ferruginous ash are burned in a reducing atmosphere. These chem. attacks are better resisted when the bricks have a close-grained structure and an even surface. To produce an even surface and density favorable to resist. it is the general practice to fire the bricks rather hard. Stress is laid on the importance of securing min. joint spaces, particularly in roofs and arches. R. M. K.

Lining of steelworks ladles. J. HRUSKA. *Fuels and Fur.*, **3** [12], 1365–67 (1925).—This article treats of a few factors affecting the life of ladle linings. The refracs. used in the ladle should have a softening point of at least cone 30. When relining a ladle the first opern. should be the tamping of the ladle with a mixt. of quartz sand, kaolin and fire clay in propns. of 1:1:1 or 2:2:1. The quartz sand should be fine and of high silica content. Kaolin is usually of a fine commercial grade and anal. Fire clay should deform from cone 31–32 and have a compressive strength of 30 lbs. per sq. in. A detailed description is given of relining procedure. It is important that ladles be dried very carefully. It is also important that the compn. of the slag be carefully controlled in order to lengthen the life of the ladle. The carefulness of use also affects the life of ladle linings. R. M. K.

Notes on "Storage of Silica Refractories." W. J. REES. *Fuels and Fur.*, **3** [12], 1382 (1925). It is pointed out that silica refrac. will deteriorate in mech. strength if not properly protected from the weather. Expts. were made using fine-grained, medium-grained, and coarse-grained bricks. Results indicated that well-fired, close-grained brick were decidedly more resistant to exposure to rain and frost than bricks which have been less thoroughly fired. R. M. K.

Refractories. M. C. BOOZE. *Fuels and Fur.*, **4** [1], 41–44 (1926).—The major purpose in the use of refracs. is the confining of heat in furs. Heat or temp. determines the use of a refrac. in any particular construction yet the life of a refrac. is often detd. by other influences. Hence it is found necessary to use a variety of mats. in making refrac. products. Several destructive influences are at work at any given time and it is difficult to select the most satisfactory product for any given service. A classification of the consumption of refracs. by industries is given. A large propn. of the total output is used

in the metallurgical indus. The life of refracs. in furs. is affected by one or more of the following: fusion, spalling, slagging, softening, mech. abrasion, shrinkage, expansion, deposition of solids within pores by gases, chem. combination with gases, compression, shearing, and tensile stresses through the direct application of loads, and the presence of an oxidizing or reducing atmosphere. It is not often necessary to pay special attention to the matter of fusion points of refracs. since this is usually considerably in excess of temps. at which most furs. operate. Tests now used on refracs. are not made under actual fur. conditions and are only approx. indicative of the properties they are designed to measure. Two possibilities for the improvement of silica brick are suggested. Future improvement in mfg. methods will likely be those that tend toward greater uniformity as to quality, shape and size. Some recent developments in the refrac. field are listed.
R. M. K.

Investigation on Canadian magnesite. F. E. LATHE. *Can. Chem. Met.*, **10** [1], 3 (1926).—An invest. is to be started at once at the Ceram. Lab. of the Mines Branch under the direction of H. FRECHETTE as to the suitability of Canadian magnesite for the manuf. of magnesite brick. The effects of impurities of lime and silica are to be studied; also the action of slags on the bricks produced. A new method of purification is to be devised.
F. G. J.

The refractories investigation. M. C. BOOZE. *Power*, **62** [20], 776 (1925).—B. takes exception to some of the statements by HELSER and BOLE in "Preliminary Findings in Refractories Investigations—Part II." He believes the tests proposed merely classify fire brick and are not "suitability" tests.
C. J. H.

Recent studies in refractories. E. B. POWELL. *Power*, **62** [23], 894 (1925).—Methods are described of various tests of fire brick for boiler work such as slag penetration, bond carrying capacities, effect of temp. of firing. Water-cooled furs. tend to eliminate refrac. troubles.
C. J. H.

The resistance of refractory materials to temperature changes. ANON. *Stahl und Eisen*, **45**, 249 (1925); *Archiv für Warmewirtschaft.* **6**, 302 (1925).—Report on paper by DR. STEGER. Importance of thermal expansion is emphasized.
E. E. P.

Refractory materials for movable grate and pulverized coal firing. ANON. *Glückauf*, **61**, 1177 (1925); *Archiv. für Warmewirtschaft*, **6**, 329–30 (1925).—Discussion of report on recent visit of ENDELL and STEGER to the United States. Properties of American refrac. clays and tests made at the Bur. of Standards are reported with particular ref. to service in boiler installations.
E. E. P.

Modernize or pass out of the picture. ANON. *Brick and Clay Rec.*, **67** [13], 930–34 (1925).—A description of the Ironton (Ohio) Fire Brick Co.'s plant is given. The raw mats. come from the Olive Hill, Ky. region. The plant has storage facilities for about 6000 T. of raw clay. The storage system consists of a hopper with plate feeder, a bracket elevator and overhead drag conveyor which drops the clay at any desired point in the pile. A reclaiming belt runs beneath the storage pile. Costs of unloading and reclaiming were reduced from 40 cents to 4 cents per ton. The flint clay and semi-flint clay are ground in dry pans separately. The clay is screened and stored in bins from which it is reclaimed through chutes with gate feed controls. The correct propns. of each clay are measured by a compartment car which is unloaded through the bottom into a wet pan. The tempered clay is distributed to the molders' benches by means of a disk feeder fed by a compartment car, two 12-foot pug mills, a brick mach., a reciprocating cutter, and a special repress. Repressing, which formerly was done in 3 operns. is done in one, in this mach. Drying is done in especially constructed, humidity-controlled tunnels which are heated by waste heat. Firing is done in five round, downdraft kilns and 3 rectangular kilns.
R. E. G.

They share profits with their labor. ANON. *Brick and Clay Rec.*, **68** [1], 44–49 (1926). —A description is given of the profit-sharing plan used by the Ashland (Ky.) Fire Brick Co. An illustrated description of the plant is also given. R. E. G.

Use of silica refractories. P. B. ROBINSON. *Jour. Soc. Chem. Ind.*, **44,** 1181 (1925). —Sets out phys. properties of silica refracs. on the appreciation of which their successful use in coal carbonization depends. Their thermal expansion depends on the relative proportion of the 3 allotropes: quartz, cristobalite and tridymite. Serious expansion troubles occur with well-fired silica bricks at temps. below 300° C. As a practical margin of safety, htg. should be slow up to 600° C. As thermal condy. of silica brick is much higher than that of fire clay, the time of carbonization can be reduced considerably by using silica. Underfired bricks contain more quartz than cristobalite, and may be used where gradual heating is impossible, and also where the refrac. is submitted to abrasion by hot dust traveling at high velocity. It is important to store silica brick in a dry atm. H. H. S.

Refractories (for water gas sets). W. M. RUSSELL. *Proc. Am. Gas. Assoc.*, **1925** (advance copy), 8 pp.—Continued tests of carborundum Bernitz blocks for water gas sets (*Ceram. Abs.*, **4** [10], 281) show them to have considerable advantages as regards long life and decreased clinkering trouble; in one case a total saving of $825 on one lining is estd. Straight carborundum linings have lasted in 2 cases reported 6687 and 5548 hrs., but special precautions must be observed in laying the brick with close joints, penetration of air into seams causing swelling even to the point of shearing the rivets on the vertical seams of the shell. (*C. A.*)

Dolomites and magnesite. J. DAUTREBANDE. *Rev. chim. ind.*, **34,** 246–9, 276–7 (1925).—Brief review of their properties and uses. (*C. A.*)

Silit. ANON. *Electrician*, **95,** 387–8 (1925).—Silit consists of an intimate mixt. of Si and SiO_2 with a volatile binder which is heated until the Si just softens. Exposure of the forms of mixed Si, SiC and C to the action of CO at 1500° produces a product of high fireproof qualities, resistant to atm. influences, and possessing high and variable sp. resistances. Three grades are made: (1) for resistances subject to permanent loads at glowing temps. and to high momentary loads; (2) for elec. htg. resistances up to 1400°; and (3) for fireproof mat. capable of withstanding violent changes in temps. Applications of each grade and several curves showing sp. properties are indicated. (*C.A.*)

The action of carbon monoxide on fire brick. GILARD. *Rev. universelle des mines de Liége*, December 1, 1923; *Le Genie civil* **84,** 457–458 (1924).—The CO penetrates the fire brick and if the brick contains Fe_2O_3 it reacts setting free C. Disintegration results American work is noted. (*C. A.*)

The electrical conductivity of magnesia refractories at high temperatures. J. T. BURT-GERRANS AND R. S. KERR. *Trans. Roy. Soc. Can.*, **19,** 27 (1925).—The sp. condy. of new magnesia bricks increases from 2×10^{-5} reciprocal ohms per cc at 870° to 5×107 at 1020° then falls to 2×10^{-5} again at 1080° and finally increases with the temp. to 0.2^{-5} reciprocal ohms at 1550°. Bricks after heating above 1400° and then cooling showed decreased condy. between 1200° and 1300° but behaved as new bricks at higher temps. (*C. A.*)

Laboratory production of pure magnesia ware. R. F. MEHL, J. L. WHITTEN AND D. P. SMITH. *Ind. Eng. Chem.*, **17,** 1171–72 (1925).—Pure MgO crucibles and tubes are made by (1) heating pure MgO for 1 hr. at 1800°, (2) mixing with shellac (12 g. orange shellac in 80 cc EtOH or MeOH, mixed with 120 g. of the previously heated MgO),

(3) pressing into mold, (4) drying at room temp. for 1 hr., (5) drying at 150° for 2 hrs. or more, (6) firing at 1800° for 1 hr. The resulting ware is excellent. (*C. A.*)

Slag reactions. P. M. MACNAIR. *Trans. Faraday Soc.*, June, 1925 (advance proof), cf. *C. A.*, **19**, 27.—In steel-making processes a heterogeneous system of four phases—solid lining, liquid metal, more or less liquid slag and fur. gases—has to be considered. The slag is in immediate contact with the other three and there must be a tendency to form equil. with each of these. Equil. between slag and lining gives the essential difference between acid and basic practice. Intimate contact between the various constituents is necessary if rapid chem. change is to take place; hence the rate is much greater in liquid than in solid or viscuos phases. Slag consisting of various oxides tends to absorb constituents from the lining and becomes more viscous, thereby setting up an "inactive" stage in the steel-making operns. due to decreased rate of reaction caused by the increased viscosity. This is not necessarily a state of equil. In acid practice the slag tends to absorb SiO_2 from the banks, or similarly alter in compn. by reduction of FeO, till at about 60% SiO_2 for open-hearth temps. it becomes viscous and inactive. This compn. is practically independent of the amts. of CaO, FeO or MnO present. In basic slags, the inactive state is reached at about 60% CaO, 40% SiO_2 and low FeO, while with increasing amts. of FeO or MnO, the SiO_2 content diminishes. The condition for stabilization of P_2O_5 in the slag is that the SiO_2 content is less than that required for the limiting slag of the same CaO, FeO content. (*C. A.*)

PATENTS

Refractory material, articles made therefrom, and method of making the same. SIMON J. LUBOWSKY. U. S. 1,567,445, Dec. 29, 1925. A mat. for use in making refrac., chem. resisting articles comprising calcined rutile with the particles in sintered union.

Method of making crucibles. ARTHUR JOHN JACKMAN. U. S. 1,570,064, Jan. 19, 1926. As an article of manuf., a crucible for a metal melting opern. wherein slag is formed, having a graphitic body portion adapted to contact with the bulk of the metal and having a portion adapted to contact with the slag and made from a mat. more resistant than the said body portion to the corrosive action of the slag, substantially as described.

Refractory oxides and alloys. T. R. HAGLUND. Brit. 232,549, April 17, 1924. Oxides such as those of Al, Mg, Cr or Zr are obtained from crude materials (which for Al, may be bauxite, clay, alundum, fire brick, feldspar, alum, shale, leptite, carboniferous clay, coal dross, etc.), by fusing a mixt. of the raw material with coke, coal, charcoal or CaC_2, a sulphide of Fe, Cu, Pb or other heavy metal or of Al, Ca, Ba, Mg or Na or a mixt. of sulphate of Ca or Ba and a sulphide. An elec. arc furnace may be used and Fe may be added if much S is present. Reducible metals and Si form an alloy which is easily separable from sulphide slag in which the refractory oxide is dissolved. The slag is cooled and treated with H_2O, acid, alkali or steam to dissolve or decompose the sulphide and leave the oxide. The cryst. product may be further purified by electrostatic or electromagnetic sepn. and treatment with acid and alkali.

Terra Cotta

Monograph and bibliography on terra cotta. HEWITT WILSON. *Bull. Amer. Ceram. Soc.*, **5** [2], 94–145 (1926).—Starting with a brief historical sketch, enumeration of advantages of terra cotta, development of surfaces and classification of the product, W. gives very detailed information regarding the manuf. of terra cotta. Under the discussion of the body are enumerated requisites, mixt., methods of mining, handling, mixing and tempering. The details of drafting and plaster work in connection with each

order are discussed. Various methods of pressing (molding the body) and finishing are enumerated, as are those of drying the ware. The storage, mixing and identification of raw mat. is taken up. Prepn. and control of sp. gr. and viscosity of slips and glazes, spraying, spraying technique and procedures are gone into in considerable detail. Underslips and glazes are discussed from all possible angles, taking up types of glazes, fit, coeff. of expansion factors, defects and their causes, etc. Color work is taken up under the sub-heads of (1) common colors, (2) polychrome colors, (3) granite finishes, (4) pulsichrome applications and (5) polychrome decoration. Kiln construction, flue arrangement, fire boxes, setting, firing, cooling and dunting, and compn. and dunting are taken up. Kiln data from the Pacific Northwest Clayworkers' Assn. is given. Treatment of the fired ware in the fitting department is given in complete detail. Ten factors of importance to the life of the terra cotta in the wall are enumerated and discussed. A bibliography of 173 ref., well-cataloged, concludes this very fine paper. E. J. V.

White Wares

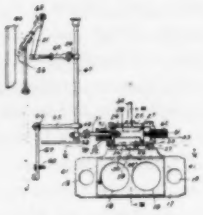
Influence of compn. of body and glaze on the physical properties of a true porcelain. PYUNGTOO WILLIAM LEE. *Jour. Amer. Ceram. Soc.*, **9** [2], 97–103 (1926).—An effort to produce a higher quality of true porcelain at cones 10 to 12. Phys. properties of body and glaze and their workabilities are observed. Tests were made for shrinkage, warpage, translucency, absorption and modulus of rupture.

Vitreous floor tile proves best surface for floors. CARL H. GEISTER. *Ceram. Ind.*, **6** [1], 47 (1926).—The article is a description and results of tests made upon various floor mats., for use in hospitals. The mats. were rated according to their resist. to rotting, checking, hardening, fading, staining, softening and tendency to give off odors at low temps. Tables are given and conclusions are drawn that tile flooring fulfills the necessary requirements. R. E. G.

Steatite. FELIX SINGER (Trans. by W. L. Shearer and A. W. Holzmann). *The Ceramist*, **7** [1], 3–13 (1925).—Steatite is a clay free subs. contg. as plastic raw mat. the magnesium silicate soapstone. S. distinguishes between real soapstone ($3MgO \cdot 4SiO_2 \cdot H_2O$ to $4MgO \cdot 5SiO_2 \cdot H_2O$) whose hardness is 1 to 2 and agalmatolith ($Al_2O_3 \cdot 4SiO_2 \cdot H_2O$) whose hardness is 2 to 3. Real soapstone is easy to work with tools but must be fired to secure hardness. Whereas talc (another magnesium silicate) is widely distributed, real soapstone is found only at Göpfersgrün-Thiersheim in the Fichtel Mountains, Germany. Soapstone is worked by (1) turning methods (2) ceramics methods. American soapstone, being harder, cannot be worked with the same accuracy. S. describes the manuf. of "Speckstein" burners which are turned from real soapstone and fired to about 900° C. By pressing soapstone powder in steel molds and firing, spark plugs and elec. insulators are produced (steatite ware). Steatite ware has high refractoriness, great exactness, great mech. strength, poor heat condy., high elec. insulation resist. and high resist. to temp. changes. In the manuf., the ball mills are lined with steatite bricks and steatite balls are used. The molded pieces are covered with a suitable leadless glaze and fired at 900° C to 1100° C. S. gives a formula indicating the limits of compn. of the glazes used, and an extensive table of the phys. properties of (1) burned steatite (2) unburned soapstone (3) powdered soapstone. Greater exactness of dimensions can be secured with steatite than with porcelain as its shrinkage during firing is only about 1%, as compared with 16 to 20% for porcelain, due to the fact that it contains only 3.74 to 4.75% chemically combined water and no water of plasticity need be added. "Melalith" is intermediate between normal porcelain and steatite bodies and is used in making larger ware. Steatite can be worked by all the methods used in porcelain technology. A. E. R. W.

PATENTS

Tile press. MILTON V. WASH. U. S. 1,566,638, Dec. 22, 1925. In a tile press, the combination of a reciprocable plunger provided with an upper die, a base block provided with two press. cylinders, an anvil mounted for vertical movement in said block and provided with a lower die, raising and lowering pistons attached to said anvil and arranged in said press. cylinders, a valve comprising a casing communicating with said cylinders and an element movable to alternate positions for alternately controlling flow of press. fluid to an exhaust from said cylinders, and means coördinated with the reciprocation of said plunger for moving said valve element.



Porcelain crucible. ALFRED KÖNIG. U.S. 1,567,654. Dec. 29, 1925. As a new article of manuf. porcelain crucible having a bottom of finely porous mat. melted together with the porcelain.

Method of preparing clay or body composition for ceramic articles. ARTHUR O. AUSTIN. U. S. 1,569,251, Jan. 12, 1926. In the manuf. of ceramic articles the process of mixing the mat. therefor, wherein a portion of the mat. is prepd. with a sufficient percentage of water to render it fluidic, and another portion is prepared in dry condition and the 2 portions are mixed together to provide a body mix, having a percentage of water slightly greater than that at which the ceram. articles are formed, the excess of water being removed by evaporation to condition the mix for forming articles.

Equipment and Apparatus

Boiler design. EDITOR. *Power*, **62** [26], 1017 (1925).—Modern boiler design is tending toward high pressures; fur. construction influences boiler design by the use of water-cooled side walls with or without refrac. lining. C. J. H.

Boilers and boiler auxiliaries. ANON. *Power*, **63** [1], 4 (1926).—Water-cooled walls for boilers have met with considerable success during last year. Numerous installations have shown that water cooling has now become a recognized method of fur. protection. C. J. H.

Radiation in boiler furnaces. B. N. BROIDO. *Mech. Eng.*, **48** [2], 133 (1926).—There is now a noticeable tendency toward an extensive application of water-cooled fur. walls for absorbing heat by radiation. An anal. of the fundamentals of radiation and of the effect of water-cooled walls on the gas temps. in a fur. is given. Descriptions are given of water-cooled walls, some of which have a partial refrac. lining. C. J. H.

Pulverized-fuel firing. ANON. *Mech. Eng.*, **48** [2], 163 (1926).—A reduction in size of fur. may be looked for with the production of refrac. to withstand higher temp. Sillimanite refracs. show considerable promise. The high price of these refracs. will come down with greater use. There is a certain min. of size of fur. below which it is undesirable to go because length of flame is highly important. C. J. H.

Fuels and furnaces in Europe. W. TRINKS. *Fuels and Fur.*, **4** [1], 19–30 (1926).—The general conditions in Europe which influence the design of furs. and the fuels used are pointed out. The following items are then discussed: high temp. carbonization, low temp. carbonization, liquefaction of coal, pulverized coal, mat. handling, fur. refracs., heating furs., sheet furs., welding, atmosphere control, and bright annealing. Under these items many different processes are described with cuts showing app. used and its general layout. The tendency in European fur. design and opern. is essentially the same as in the U. S. with the exceptions caused by the relatively lower cost of labor

and the relatively higher cost of fuel. These invest. show that no nation can permanently keep far ahead of another in design and opern. of furs. R. M. K.

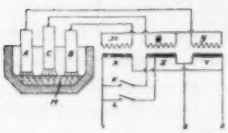
Industrial pyrometry. ANON. *Jour. Soc. Chem. Ind.*, **44**, 1157–59 (1925).—Deals with pyrometry in tunnel kilns, periodical kilns, glass-tanks, annealing ovens, enameling furs., cement kilns, open-hearth furs., and oil-cracking stills. H. H. S.

Improved form of electric vacuum furnace. J. R. PARTINGTON AND N. L. ANGILOFF. Farady Soc. Meeting Nov. 16; *Jour. Soc. Chem. Ind.*, **44**, 1164 (1925).—The fur., modelled on the Ruff type, is found to be the most satisfactory vacuum fur. of the type, for studying reactions at high temps. The reacting subs., if solids, are contd. in a graphite crucible turned from the same mat. as the hot tube and maintained either in a high vacuum or in an atm. of an inert or reacting gas. The issuing gas is capable of anal. if desired. H. H. S.

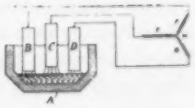
New method for determination of porosity. P. B. ROBINSON. *Jour. Soc. Chem. Ind.*, **44**, 1181 (1925).—The sample is weighed and then coated with an impervious layer of plasticene or other suitable wax. The sample is then weighed in air and in water, and, the d. and wt. of the plasticene being known, the d. of the sample is calcd. The sample is then powdered, and the d. of the powder detd. as usual. $P = 100\ (1-D/S)$, where P is per cent porosity, D apparent density before powdering, S d. after powdering. H. H. S.

PATENTS

Electric-arc furnace. JOSEPH L. DIXON. U. S. 1,569,463, Jan. 12, 1926. In a system of the kind described, the combination with an elec. fur. of three upper electrodes and a transformer of 3-phase alternating currents having transformer ratios of unequal values in the several phases, and supplying said electrodes with currents of different voltage.



Electrothermic refining of metals. JOSEPH L. DIXON. U. S. 1,569,464, Jan. 12, 1926. The process of refining steel by means of an electric arc fur. having a plurality of electrodes which consists in supplying between one electrode and another current of low voltage and between other of said electrodes current of relatively high voltage.



Kilns, Furnaces, Fuels and Combustion

Insulation of ceramic kilns. WALTER KENNEDY. *Jour. Amer. Ceram. Soc.*, **9** [2], 114–19 (1926).—The early methods of reducing radiation losses by building very thick walls and by building so-called "dead-air spaces" into the walls are discussed. Ideal insulation for kilns, etc., should have the following properties: (1) high heat insulating value, (2) sufficient refractoriness to retain form and efficiency when subjected to high temp., (3) sufficient mech. strength to resist wall strains due to expansion and contraction of the brickwork with changing temp., (4) approx. the same coeff. of expansion as the brickwork, (5) light wt. Thorough insulation is stand. in tunnel kiln construction. Crowns of periodic kilns are insulated with $2\frac{1}{2}$ in. brick which weigh $1\frac{3}{4}$ lbs. each, side walls with $4\frac{1}{2}$ in. of insulating brick or insulating powder $4\frac{1}{2}$ in. in thickness built into the wall between the refrac. brick and the outside wall. Bases are usually insulated by using one or two $2\frac{1}{2}$ in. layers of insulating brick or 5 in. of insulating concrete composed of calcined insulating mat. and Port. cement. Advantages of kiln insulation are (1) improved quality of firing, (2) reduction in firing time, (3) longer life of crowns, walls, and fire pockets, (4) savings in fuel of app. 16–17% over uninsulated kilns. E. J. V.

Relation between heating value of gas and its usefulness to the customer. E. R. WEAVER. Bur. of Standards, *Tech. Paper*, **290**. The paper contains a critical review of

available data regarding the relative usefulness of gases of different heating value. The sources of mat. have been limited to published data, official reports, and mat. which have been submitted as evidence to national, state, or municipal bodies in connection with hearings on rates or standards. Data shows that the same amt. of potential heat is equally useful regardless of the volume, compn., or other properties of the gas in which the potential heat is conveyed and the appliance in which it is fired. Data also shows that the amt. of heat used by the community is not affected materially by a change of htg. value of the gas supplied. S. S. C.

Gas burner design. GEO. GIBSON. *Fuels and Fur.*, **3**, 1344–46 (1925).—In a gas burner such as the Bunsen type, the gas, before issuing from the burner ports, induces the air necessary for combustion. In producing a given type of flame with a given quality of gas, the detg. factor is the ratio of air induced to gas. An equation is derived showing the relation of the air-gas ratio to the gas press., the air and the gas densities, and the burner constants. For convenience in detg. the amt. of air to be premixed a set of curves giving premixed air against total air for different gas densities can be drawn up. By the intelligent use of these curves in the regulation of the burners the desired qual. of flame or fur. atm. can be obtained. A set of such curves can be made from the given equation after detg. only four points experimentally to fix the constants. A 2nd curve can be used to set the press. of distribution to insure the correct heating value or B.t.u. delivered through the burner, or the latter can be regulated by means of a single throttling valve. It will not be necessary for him to make any changes in the air or gas ports of the burner itself which will automatically give the correct mixt. of all rates of firing. R. M. K.

Tunnel kilns for firebrick production. W. POHL. *Feuerfest*, **1** [11], 190 (1925).—Further description of the "Kerabedarf" tunnel kiln. Exit gas temp. 150–200° C. Rate of cooling in diff. zones sharply controlled. F. A. W.

Contributing factors to efficient oil firing. L. A. MEKLER. *The Ceramist*, **7** [3], 127–41 (1925).—Most of the features of present day kilns have been developed to give efficient firing with coal. M. outlines the changes that must be made in the number and size of fire boxes, the size of the combustion chambers and the flue and stack area when the change is made from coal to oil. Of five types of oil burners described, the multiple atomizing burner is considered the best. The oil pumps should have ample capacity and deliver the oil without pulsation. A screw rotary pump gives the best results, especially when used with the return line arrangement which is described. The oil should be heated. A constant air supply should be maintained by means of a centrifugal or a multi-stage turbine blower. The best method of firing is given in detail. The gases of combustion should contain 12 to 14% CO_2 and the firing cycle adjusted as described so as to give the max. temp. gain with the least number of gal. burned. In an example given, the oil consumption per burn was reduced from 5940 to 4200 gals. by making the changes suggested in this paper. A. E. R. W.

Compartment kilns and annular kilns. A. MENDHEIM and E. REUTLINGER. (Trans. by W. L. Shearer and A. W. Holzmann). *Ceramist*, **7** [3], 142–49 (1925).—The construction and opern. of compartment kilns and annular kilns are described and the disadvantages and advantages of firing certain types of ceramic ware in such kilns pointed out. A. E. R. W.

Getting the highest return from kiln equipment. JOHN R. GREEN. *Clay Worker*, **84** [7], 595–96 (1925).—Pyrometers are discussed under (1) equipment, (2) installation, and (3) use. It is claimed that the use of pyrometers effects (1) savings in fuel by more effective firing, (2) savings in time and increased turnover by controlling the heating-up, soaking and cooling periods, (3) decreased depreciation of the kiln by more uniform rates of heating and cooling, and (4) increased quality of the ware by correct firing treatment. R. E. G.

High-frequency induction furnaces for high temperatures. G. RIBAUD. *Compt. rend.*, **180,** 1733–35 (1925).—R. made a study of furnaces having, in principle, a porous C cylinder extending above the graphite heating chamber, all of which is surrounded with lamp black. He describes the method of closing the cylinder which made it possible to attain a temp. of 3000° in the interior of the fur. The results show that a 10 kw. high frequency fur., with a vol. of 500 cm.³, may reach a temp. of 2500° as compared with 1700° for a C resist. fur. of like vol. and kw. capacity; with a vol. of 100 cm.³ a temp. of 3000° was attained. One of these fur. has been used for the transformation of the diamond and has produced more than 50 heats at 2000° without the replacement of porous C. These fur. have been used for calcining refracs., for detg. points of fusion, etc. (*C.A.*)

Contribution to the study of the gas producer. G. HUSSON. *Rev. ind. minérale* (1925), 451–72.—A discussion of the *theoretical relations between the temp. gradient of a gas producer using coke and the compn. of the gas,* with their application to the practical opern. of the producer. In effect the article is an amplification of a previous one (cf. *C. A.* **16,** 4327). The determinant factors governing the opern. of such a producer are the insulation of the equipment, the reactivity of the coke and the softening temp. of the ash, the first two of which have heretofore been too little appreciated. The insulation dets. the temp. of the zone where the ratios CO/CO_2 and H/H_2O are max. and the rate at which combustion should be carried on to obtain max. efficiency. It is shown to be of great advantage to have a very reactive coke and so a gas producer using coal should be so operated that the distn. in the upper region yields a coke of max. reactivity. Theoretically ideal conditions are modified in practice by the fact that the softening point of the ash limits the temp. of the hot zone, the efficiency becoming less above this temp. because of mech. troubles caused by fusion of the ash. Further considerations, such as the effects of steam injection, the max. temp. of combustion and the application of the theories derived for coke gas producers to producers using coal, are discussed in a way which does not admit of brief exposition. (*C. A.*)

Thermodynamic and industrial bases of pulverized coal combustion. ROSIN. *Combustion,* **13,** 94–5 (1925); cf. *C. A.* **19,** 2735.—As with other forms of coal, the combustion of pulverized coal is a surface phenomenon. The ratio of the surface of the individual particle to its wt. is related to the combustion period by an hyperbolic curve. The disturbing influence of ash on combustion is not thermodynamic in nature but is due to the reduction in effective surface of the coal by the ash constituents. The combustion chamber must meet 2 fundamental specifications: (1) The fuel must burn completely in it. (2) The temp. of the inner refractory walls must be below their softening point, *i.e.*, there must be a transfer of heat to the body to be heated immediately after flame production. (*C. A.*)

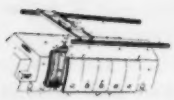
The length of visible flame and length of flame travel in combustion of powdered coal. HENRY KREISINGER. *Ind. Eng. Chem.*, **17,** 1232–33 (1925).—The length of the visible flame depends on the volatile matter of the coal, its compn., the amt. of primary air, and the method of mixing the coal and air. The combustion of the coke particles after the volatile matter has been driven off gives no visible flame, so that the length of visible flame is no general guide to proper operation. The velocity of combustion of powd. coal is mainly dependent on the rate and manner of mixing of the gases and the fuel during combustion. (*C. A.*)

The development of a unit pulverizer for coal). R. S. RILEY AND OLLISON CRAIG. *Mech. Eng.*, **47,** 1045–52 (1925). (*C. A.*)

Progress in fuels engineering. O. P. HOOD, *et al. Mech. Eng.*, **47,** 1124–26 (1925). (*C. A.*)

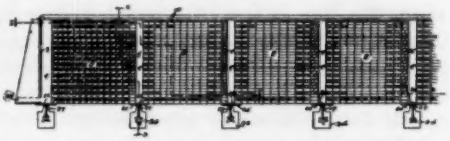
Pulverized fuel for boilers and furnaces. W. R. CHAPMAN. *Fuel in Science & Practice*, **4**, 396–400, 420–24 (1925); cf. *C. A.* **19**, 3361.—A discussion of the proper lining of the combustion chamber, the disposal of the ash, the suitability of different types of fuels, the efficiency of pulverized coal and a comparison with other methods of firing. *Ibid*, 486–92.—A general discussion of the value of pulverized fuel under various conditions and the results obtainable in comparison with those with gas. (*C. A.*)

PATENTS



Apparatus for firing bricks. WILLIAM W. DICKINSON, JR. U. S. 1,569,952, Jan. 19, 1926. A kiln scoving consisting of rigid rectangular independently movable panels of non-metallic heat-resisting mat. supported in upright position upon the exterior of the kiln, each of said panels bowed outwardly between its upper and lower ends and the body of the kiln being sloped to conform approx. therewith.

Apparatus for firing bricks. WILLIAM W. DICKINSON, JR. U. S. 1,569,953, Jan. 19, 1926. In kiln construction, the combination with parallel side walls, of cross walls connecting the same and having openings at their bottoms, bricks built within said walls in open-work relation, said bricks spaced from one side of each cross wall to define an open flue with which said openings communicate, and said walls being built up with and supported by and removed with said bricks, means for drawing air through successive kilns, and means for burning fuel in said flues in front of said openings.



Tunnel oven or kiln. H. FRANCART. U. S. 1,557,040, Oct. 13. (*C. A.*)

Geology

The minerals of bentonite and related clays and their physical properties. C. S. ROSS AND EARL V. SHANNON. *Jour. Amer. Ceram. Soc.*, **9** [2], 77–96 (1926).—Bentonite is a very widely distributed clay mat. that is the result of the devitrification and chem. alteration of glassy volcanic ash or tuff. Bentonite should be used as the name of a rock derived from volcanic glass and it is commonly composed of the mineral montmorillonite but less often of beidellite. Its characteristic minerals are completely crystalline and have a micaceous habit, high birefringence and facile cleavage. It contains no gel colloids, and few of its cyrstal particles are so small as to reach "colloidal size." It shows high adsorptive powers and this property is more dependent upon phys. form than upon chem. compn. That is upon the micaceous structure and easy cleavage which give very great surface area and the felt-like texture which facilitates permeability. The clay minerals of the type here described resemble the micas in many ways, but do not seem to possess the marked chem. variability of that group. A large number of anal. of the clay minerals from bentonite indicate that the most widespread of these is montmorillonite with the formula $(Mg, Ca)O \cdot Al_2O_3 \cdot 5SiO_2 \cdot nH_2O$. A reanal. of the type montmorillonite from Montmorillon, France, gives the same formula, and the mineral has also been recognized in lithium-bearing pegmatites and in fullers' earth. A few bentonites are composed of beidellite, a mineral first identified from the gouge clay of ore veins. It has the formula $Al_2O_3 \cdot 3SiO_2 \cdot nH_2O$ where n = about 4, and Al_2O_3 may be partly replaced by Fe_2O_3. A third micaceous clay mineral has the compn. of halloysite $Al_2O_3 \cdot 2SiO_2 \cdot nH_2O$, but it is completely and visibly crystalline and has a high birefringence.

Chemical composition and optical properties of beidellite. C. S. ROSS AND E. V. SHANNON. *Jour. Wash. Acad. Sci.*, **15**, 467 (1925).—Beidellite occurs in three distinct

modes of formation, *i.e.*, (1) gouge clays at Beidell, Colo. and Owyhee Co., Idaho and flourite veins Wagon Wheel Gap, Colo., (2) Jones Falls, Baltimore, Md., formed by alteration of zeolites and (3) forms the claylike ground mass of some bentonites at Nashville, Ark., and at Spokane, Wash., it is interbedded with basalt flows. Beidellite from Beidell, Colo. had the following optical properties α 1.494, β and γ 1.536, α–γ 0.042. Anal. of various samples are also given. S. S. C.

The industrial uses of zirconium ores. M. F. BERTRAND. *Rev. universelle mines*, **7** [7], 218–34 (1925).—The occurence, properties and anal. of Zr ores, the prepn., phys. and chem. properties and uses of Zr, the value and use of ZrO_2 and Zr silicate as refrac., the manuf. of porcelain and enamels with ZrO_2 and various other uses of ZrO_2 are described. (*C. A.*)

Chemistry and Physics

Kaolin. (1) Thermal changes. (2) Rational analysis of clay. K. A. VESTERBERG, etc. *Ark. Kemi. Min., Geol.*, **9**, 1–26 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 959 (1925).—Kaolin on htg. to 800° does not decompose into free Al_2O_3 and SiO_2, but forms $Al_2Si_2O_7$, which is sol. in HCl. On htg. kaolin to 1000° the product is completely insol. in HCl. Glagerite ($Al_2O_3 \cdot 2SiO_2 \cdot 2.55H_2O$) differs from kaolin in that it is 50% sol. in 20% HCl, and is rendered completely sol. by htg. to 750°. Pyrophyllite differs from both the other minerals in that it is not rendered sol. by heating. (2) The rational method recommended is: 1 gm. clay is heated for 1 hr. with 10 cc 20% HCl, and the undissolved portion is again subjected to the same treatment, part of it direct, and the remainder after htg. to 800°. Sol. Al_2O_3 is detd. in the HCl soln., and the sol. SiO_2 in the residue is extracted by boiling with 50 cc of 5% Na_2Co_3, 0.5% NaOH, and 25 cc 5% KOH. The differences between the Al_2O_3 and SiO_2 values obtained before and after heating give the Al_2O_3 and SiO_2 present as kaolin (they should be molecularly 1:2) and the kaolin is calculated by multiplying Al_2O_3 by 2.533. Anal. of clays from Sweden and Germany gave kaolin contents varying from 73.9% to 1.65%. H. H. S.

Theories on the constitution of natural silicas. G. N. RIDLEY. *Chem. News*, **131**, 305 (1925).—The fact that Si like C possesses the property of forming chain and ring systems has brought forth theories as to formation of various silicates. R. gives the 3 states of chem. combination of natural silicates: doubles salts like alums; salts of complex alumino-silicic acids; isomorphous mixts. of silicates. R. gives the funds. of ring and chain formations of Si and refers to the work of Tschermak, Groth, Loew, Asch and Kipping in discussing the theories, If these theories prove to be true a possible use may be found in cement manuf., etc. S. S. C.

Rapid determination of phosphates. R. F. LE GUYON AND R. M. MAY. *Bull. Soc. Chim.*, **37**, 1291–93 (1925); *Jour. Soc. Chem. Ind.*, **44B**, 388 (1925).—The phosphate is pptd. from soln., which may contain chlorides, by $AgNO_3$ in presence of sodium acetate. The ppt. is dissolved in concd. HNO_3, and the Ag content of the soln. detd. by titration with ammonium thiocyanate. H. H. S.

Rapid (density) method for determining bauxite content of refractory brick. J. A. L. *Rev. Mat. Constr. Trav. Pub.*, **193**, 236–37B (1925).—The apparent d. of clay products varies between 1.5 and 2.4 whereas the true d. (by powder method) is in the neighborhood of 2.67 and does not exceed 2.72. The apparent d. of bauxitic products varies between 1.9 and 2.2 while the true d. is between 3.1 and 3.2. By detg. the true d. of a mat., an estn. of its bauxite content can be made, assuming that each addition of 10% bauxite causes an increase in true d. of 0.05 above 2.72. The (1) apparent and (2) true d. of three refrac. brick exemplify: Belgian (1) 2.13 (2) 2.820, English (1) 2.09, (2) 2.647, French (1) 2.18, (2) 2.643. The Belgian brick contains about 20% bauxite. L. N.

Formation of mullite from cyanite, andalusite and sillimanite. J. W. GREIG. *Amer. Jour. Sci.*, **11** [61], 1–26 (1926).—The 3 minerals, cyanite, andalusite and sillimanite are

decomposed on heating to mullite and silica, or to mullite and siliceous liquid. The silica is probably cristobalite. The lowest temp. at which these alterations take place are different for the 3 minerals; cyanite alters at the lowest temp., sillimanite at the highest. For all three there is no definite temp. at which the mineral decomposes sharply to the new phases, and below which it remains unaffected for an indefinitely long period. In the cases of cyanite and of andalusite the alteration commences on the surfaces of the grains and advances inward. In that of sillimanite the change seems to take place throughout the grain. In all 3 minerals the rate of decompn. increases rapidly with rise of temp. When andalusite and sillimanite are decomposed the newly formed mullite crystals are oriented parallel to the original crystals. With cyanite this orientation is detd. by the surfaces from which the mullite grows. The decompn. of cyanite and of andalusite is shown to be accompanied by an absorption of heat. In all 3 cases the new phases formed are of lower density than the original mineral, so there is an expansion accompanying the decompn. Diagrams, tables and microphotos. are given. H. G. F.

Making thin sections of rocks. MARY G. KEYES. *Amer. Jour. Sci.*, **10** [60], 538–50 (1925).—Methods used at the U. S. Geol. Surv. of prepg. thin sections of rocks are described. Regular methods for firm rocks are given as well as special methods for fragile rocks and rocks contg. water sol. or minerals altered by heat. H. G. F.

Structure of ultramarine. M. DOMINIKIEWICZ. *Rocz. Chem.*, **5,** 308–39 (1925); *Jour. Soc. Chem. Ind.*, **44B,** 964 (1925).—The structure of the ultramarine mol. is essentially the same as that of kaolin, with the addition of S, which is combined with both Al and Si atoms in the mol. The coloration of ultramarine is explained on the same lines as that of org. dyes, the alumina-silicate radical being the chromogen, pholysulphide bindings of the type: Al. S.S.Al: being the chromophors, and sulphide groups of the types: Al.S.Na and Si.O. SNa being the auxochromes. H. H. S.

A source of error in the mechanical analysis of sediments by continuous weighing. J. R. H. COUTTS AND E. M. CROWTHER. Faraday Soc. Meeting Nov. 16. *Jour. Soc. Chem. Ind.*, **44,** 1164 (1925).—Attention is drawn to a tacit assumption in detg. the size distribution curves of suspensions by the method of continuous weighing of the sediment accumulated on a balance pan hung near the base of a column of suspension. The low density of suspensions immediately below the pan after the sedimentation has proceeded for a few minutes sets up a flow of liquid which interferes with the free vertical fall of the particles. The extent of the disturbance varies with the size of particles and thus distorts the distribution curve. H. H. S.

Influence of electrolytes on the plasticity of clays. C. MIRA. *Rev. Mat. Constr. Trav. Pub.*, **190,** 156–57B, **191,** 177–79B (1925).—A review of Amer. and European lit. with a detailed account of the article by J. D. BRUMBAUGH on "The effect of electrolytes on plastic clay" in *Brick and Clay Record* **62,** 221 (1923). See *Ceram. Abs.* **2,** 108 (1923). L. N.

Adsorption of acids by purified silica. J. N. MUKHERJEE. *Nature*, **115,** 497 (1925).—M. showed in *C. A.*, **19,** 1320, that hydrated silica free from all impurities adsorbs acids. Data are now given to show that thoroughly washed hydrated silica, prepd. from pure $SiCl_4$ and allowed to be partially dehydrated in air at room temp., exhibits a marked increase in its capacity to adsorb acids. (*C. A.*)

The determination of uranium. G. E. F. LUNDELL AND H. B. KNOWLES. *J. Am. Chem. Soc.*, **47,** 2637–44 (1925).—Contrary to prevailing prejudices, the volumetric method for detg. U is accurate provided a cool, acid soln. is passed through a Jones' reductor and sufficient time is allowed for atmospheric oxidation before titration with $KMnO_4$. The reduction is then to the quadrivalent state. The soln. should contain 1% or less of U and 5% of H_2SO_4. Similarly the gravimetric method of pptg. with

NH_4OH and weighing as U_3O_8 is accurate but it is advisable to add macerated paper pulp; there is no need for special ignition in H_2 or in O_2. A residue of U_3O_4 can easily be tested volumetrically by titrating with $KMnO_4$ after dissolving in HF and H_2SO_4 and adding boric acid. (*C. A.*)

Advances in electrochemistry in the last ten years. FRIEDRICH MÜLLER. *Z. angew. Chem.*, **38,** 766–71, 865–68, 933–41 (1925). (*C. A.*)

Silica gel, its properties and apparatus for using it. F. W. HORST. *Chem. App.* **12,** 159–61, 201–2 (1925); 7 cuts. (*C. A.*)

An X-ray investigation of some finely divided minerals, artificial products, and dense rocks. F. RINNE. *Z. Krist.*, **60,** 55–69 (1924).—The X-ray diffraction patterns are described (but not analyzed) for: bauxite, hydrargillite, diasporite, Al_2O_3, Fe_2O_3, SiO_2, opal, V_2O_5, kaolin, allophane, talc, serpentine, meerschaum, calcite, aragonite (flos-ferri), vaterite, magnesite, hydrozincite, turquois, boracite, stassfurtite, org. compds. such as asphalt, ozocerite, and dopplerite, and rocks, such as limestone, flint, obsidian, etc. (*C. A.*)

New apparatus for the determination of carbon dioxide in flue gases. CAILLOT. *Rev. ind. minerale*, Jan. 15, 1924; *Genie civil*, **84,** 415 (1924).—As the CO_2 increases in the flue gases their heat condy. decreases. Two Pt wires, one in the air and one in the flue gases, are heated by the same elec. current. The wire in the flue gases gets hotter as the CO_2 increases and its resist. increases. The amt. of CO_2 and the resist. therefore vary similarly. A recording galvanometer is used. (*C. A.*)

The Powell and Parr method for the determination of sulphur compounds in coal. T. G. WOOLHOUSE. *Fuel in Science & Practice*, **4,** 454–56 (1925).—The method of Powell and Parr (cf. *C. A.* **14,** 112) was used for the anal. of 12 coals of different types, as a result of which several conclusions are drawn. The dil. HNO_3 appears to be a complete solvent for the Fe compds. since the residues after extn. with HNO_3 contained no Fe. With some coals the theoretical value for pyritic S is greater than the value detd., suggesting either that in these coals the difference between the Fe sol. in HNO_3 and that sol. in HCl is not true pyritic Fe, or that the formula for Fe pyrites in coal is not FeS_2 but intermediate between FeS and FeS_2. With other coals the theoretical value for pyritic S is less than the detd. value, suggesting that the org. S in these coals is attacked by HNO_3. The method in general is fairly accurate, but it seems desirable always to est. Fe values together with S values so that some idea of the probable error involved may be obtained. The nature of the Fe compds. sol. in HCl varies from sample to sample and includes ferrous compds., derivs. of hydrated ferric oxide and ferric compds. Complete analytical data are given. (*C. A.*)

A routine apparatus for the determination of volatile matter in coal. A. E. BEET. *Fuel in Science & Practice*, **4,** 382 (1925).—A set of SiO_2 crucibles (inside top diam. 24 mm., bottom 21 mm., height 39 mm., projections outside 27 mm. from bottom) with SiO_2 lids, resting in a SiO_2 rack and contg. 1 g. of sample in each crucible, is heated in an elec. muffle for 7 min. at 900°. The gases from the distn. are sufficient to maintain a reducing atm. Parallel expts. with Pt crucibles showed no appreciable differences in results. (*C. A.*)

Modulus of elasticity, temperature and melting point. W. WIDDER. *Physik Z.* **26,** 618–22 (1925).—The modulus of elasticity is assumed to be a linear function of the temp. and approaches zero at the m.p. The m.ps. of a paraffin and a wax are thus detd. to be 45.1° and 49.0°, resp. After correlating the data in the literature on the modulus of elasticity, and with the above assumptions, W. calcs. the m.ps. of Fe, Cu, and Al to be: 1532.8°, 1083.6°, and 657°, resp., which are in very good agreement with the exptl. results. The testing of this method for other metals must await more accurate exptl. data on the variation of the modulus of elasticity with the temp. (*C.A.*)

The spectral pyrometry of glowing bodies. HERMANN SCHMIDT. *Mitt. Kaiser-Wilhelm-Inst. Eisenforsch. Düsseldorf*, **6**, 61–9 (1925).—A mathematical paper which shows that the comparison of the intensity and color of the rays of an optical radiator with the rays of a black body leads to a varying definition of the temp. *S*. $S_m < T < S_F$, where S_m is the temp. of the monochromatic rays, T is the temp. of the radiator, and S_F is the color temp. A higher and lower limit for T cannot be detd. from the spectral position of the energy max. in union with the Wien displacement law and the analogous law for bright Pt. T cannot be detd. from the intersection point of the logarithmic isochromatic lines so long as their absorption behavior in dependence on wave length is unknown; temp. detn. from the position of the ray max. is somewhat successful. S_F is detd. from the intersection of the isochromatic lines; and in case the color temp. is independent of the wave length, by the position of the ray max. (*C. A.*)

The separation of zirconium from iron. P. WENGER and M. MÜLLER. *Helvetica Chim. Acta*, **8**, 512–13 (1925).—When ZrO_2 is fused with soda, some Na zirconate is formed which is insol. in water but sol. in hot HCl. For technical work, however, the Zr can be sepd. fairly well from Fe, Si, etc., with a loss of only about 0.5% ZrO_2 as follows: Fuse the sample with 6 times as much soda in an open Pt crucible for 2 hrs. Extract the melt with warm water, filter and wash with dil. NH_4NO_3 soln. Ignite the residue strongly and digest 2 hrs. with concd. HCl on the water bath. After dilg. and filtering nearly all the ZrO_2 remains unattacked. (*C. A.*)

Tenth list of new mineral names; with an index of authors. L. J. SPENCER. *Mineralog. Mag.*, **20**, 444–77 (1925).—S. lists 167 new names that have appeared since 1922. A brief description including compn. and ref. to the original article is given in each case. (*C. A.*)

Iron coloration in rocks and minerals. G. R. MACCARTHY. *J. Elisha Mitchell Sci. Soc.*, **41**, 135–37 (1925).—Anal. of Fe-bearing rocks and minerals and calcn. of the ferrous-ferric ratio led to the following conclusions: Ferrous compds. occurring in rocks and soils are colorless or nearly so. Ferric compds., are brown, red or yellow according to the concn. Hydrous ferroso-ferric compds. are blue. The black color of certain Fe minerals may be due to dehydration of ferroso-ferric compds. Mixts. of ferroso-ferric with large and small proportions of ferric compds. are colored purple and green, resp. Three references appended. (*C. A.*)

Ferric acid and ferrates. L. LOSANA. *Gazz. chim. ital.*, **55**, 468–97 (1925).—K_2FeO_4 was prepd. by 2 methods: (1) according to Fremy Fe powder was thrown into fused KNO_3: the yield is small; (2) a rapid current of Cl_2 was passed through a suspension of $Fe(OH)_3$ in concd. KOH. K_2FeO_4 is insol. in KOH but the product contains $Fe(OH)_3$ and KOH, which cannot be removed by washing. CO_2 decomps. K_2FeO_4 easily. A soln. of K_2FeO_4 with $Ba(NO_3)_2$ ppts. $BaFeO_4$, which is even more sensitive to CiO_2. Ag_2FeO_4 was best prepd. by suspending 5 g. finely powdered $BaFeO_4$ in 50 cc boled H_2O. To this was added the calcd. amt. of $AgNO_3$ in 50 cc H_2O. After 6 hrs. the red $BaFeO_4$ had disappeared and black Ag_2FeO_4 remained. Hg_2FeO_4 was prepd. similarly. A 2.5% soln. of $TlNO_3$ reacting as above with $BaFeO_4$ gave a brown powder, a mixt., of 2 compds. $SrFeO_4.2H_2O$ and $CaFeO_4.2H_2O$ were prepd. like $BaFeO_4$. 2% $Hg(NO_3)_2$ with $BaFeO_4$ as above did not give $HgFeO_4$. $CuFeO_4$, $PbFeO_4$, $ZnFeO_4$, $NiFeO_4$, $CoFeO_4$ $Fe(FeO_4)$, $Al_2(FeO)_3$, $Fe_2(FeO_4)_3$, $Cr_2(FeO_4)_3$, $Th(FeO_4)_2$ were all prepd. similarly. A detailed study of the properties of these compds. was made. The salts of Ag, Ba, Sr, Ca, Cu, Pb, Zn, Ni, and Co could be dried without decompn. and analyzed; their thermal decompn., was studied systematically. Those of Fe'', Fe''', Al and Th were too unstable to be dried. With Mn, Tl and Hg^I definite products could not be obtained; Mg does not react at all. The ferrates of Ba, Sr, Ca and Cu contain H_2O that is held even when they are dried to const. wt. over H_2SO_4. Those of Ba and Sr lose this H_2O at temps. below the decompn.

temp., and therefore these can exist in the hydrated and anhydrous state. Those of Ca and Cu lose this H_2O in the evolution of the active O_2. The thermal decompn. of the ferrates takes place according to the following reactions: (1) $4M_2FeO_4 \rightarrow 4M_2O + 2Fe_2O_3 + 3O_2$; (2) $4MFeO_4 \rightarrow 4MO + 2Fe_2O_3 + 3O_2$; (3) $4M_2(FeO_4)_3 \rightarrow 4M_2O_3 \rightarrow 6Fe_2O_3 + 9O_2$; (4) $2M(FeO_4)_2 \rightarrow 2MO_2 + 2Fe_2O_3 + 3O_2$. The active O_2 is always $\frac{3}{8}$ of the total O present. $Fe(FeO_4)$ is an exception to this rule. The active O_2 is only $\frac{1}{4}$ of the total amt. and this may be interpreted by 2 successive reactions: (1) $4FeFeO_4 \rightarrow 2Fe_2O_3 + 4FeO + 3O_2$; (2) $4FeO + O_2 \rightarrow 2Fe_2O_3$ and by adding these $4FeFeO_4 \rightarrow 4Fe_2O_3 + 2O_2$. The temperature of decompn. of the various ferrates is variable: the Ba salt loses H_2O at 108° and decomps. at 123°, while the Sr and Ca salts decomp. at lower temps. and those of Ni and Co are decompd. at 30°. All of these compds. decomp. continuously when heated to the proper temp. except $BaFeO_4$. The decompn. of $BaFeO_4$ at 123° proceeds to a compn. corresponding to $BaFeO_3$ and remains unchanged until 144° is reached, when it gives up the remaining calcd. amt. of active O. The compds. of univalent metals are unstable and those of the bivalent metals behave irregularly. The ferrates of the tervalent metals are more unstable than those of the bivalent metals and less than those of the quadrivalent metals. Some of the ferrates remain unchanged when kept *in vacuo* over H_2SO_4 at 15–20°, while others lose H_2O and active O. The compds of Ba and Sr lose neither H_2O nor O_2; those of Ca and Pb give a slow but complete decompn.; the salts of Ag, Cu, Zn, Co and Ni change rapidly; nothing can be said about the decompn. of the others, because they changed too rapidly. The compd. $FeFeO_4$ showed phys. and chem. properties by which it could be identified as FeO_2 prepd. in another way by Pelline and Meneghini (*Gazz.* **39,** I, 381 (1909); cf. *C. A.* **4,** 428). In $Fe_2(FeO_4)_3$ the ratio Fe:O was greater than 2. In some cases in which the products are capable of secondary oxidations various final products are obtained. In the case of Mn a mixt. of various higher oxides is probably obtained and with the Cr salt H_2CrO_4 seems to be formed. Other work on these compds. is under way. (*C. A.*)

Relation of texture and composition of clays. F. F. GROUT. *Bull. Geol. Soc. Am.*, **36,** 393–415 (1925).—Twelve Minnesota clays were sepd. mechanically into 5 fractions and each was analyzed. SiO_2 tends to conc. in the sand (0.05–0.5 mm.) while Al_2O_3, Fe_2O_3 and K_2O tend to conc. in the finer sizes (silts and clays). CaO, MgO, Na_2O and K_2O vary erratically. Kaolinite and ferric minerals are more abundant in the finer sizes; quartz and carbonates are less abundant. (*C. A.*)

BOOK

A comprehensive treatise on inorganic and theoretical chemistry. Vol. VI Pt. 2. *Si, Silicates.* J. W. MELLOR. Pp. x+1024. London: Longmans, Green & Co., 1925. Price 63 s. H. H. S.

PATENTS

Production of aluminum chloride. LOUIS BURGESS. U. S. 1,566,269, Dec. 22, 1925. The process which consists in subjecting aluminum silicid mat. to the action of dry hydrochloric acid gas under conditions causing a reaction between the same resulting in aluminum chloride.

Method of producing alumina. RUDOLF JACOBSSON. U. S. 1,570,353., Jan, 19, 1926. Method of producing alumina, comprising vaporizing the water of crystallization from hydrous aluminum sulphate without fusing the salt, and then heating the anhydrous sulphate to such temp. that the sulphuric acid is driven off, the remaining product being alumina of high porosity.

General

An ultramicroscopic motion picture study of the relation of colloidal content and plasticity in clays. WESLEY G. FRANCE. *Jour. Amer. Ceram. Soc.*, 9 [2], 67–76 (1926).

—Many attempts have been made to account for the plasticity of clay on the basis of colloidal content. If these are warranted then one should find characteristic differences in the colloidal fractions of clay suspensions, when examined ultramicroscopically. Furthermore these differences should serve as an indication of the plasticity. Ultramicroscopic motion pictures were taken of the colloidal fractions of the aqueous suspensions of four clays having different plasticities. Marked differences were found in each instance, which indicated the relative order of the decreasing plasticity of the clays examined to be: English china clay; South Carolina kaolin; North Carolina kaolin; and fireclay semi-flint. These results tend to support the idea that a definite relation exists between the colloidal content of a clay and its plasticity. Suggestions with reference to the extension of this work are made.

Ceramic education as applied to the refractories industry. M. C. Booze. *The Ceramist*, **7** [1], 39–40 (1925). B. states that the most evident weakness of a ceramic graduate when entering upon a particular branch of the industry is his lack of specialization and unfamiliarity with mfg. methods, properties of the products and their uses. B. would require specialization when at college. A. E. R. W.

Packing and handling barrels and casks for pottery. C. M. Bonnell, Jr. *The Ceramist*, **7** [1], 14–22 (1925).—In the design of a container a factor of safety should be included to take care of an occasional shock greater than has been considered reasonable. B. discusses proper packing of containers and methods of handling by manufacturers and railroad employees. Casks should be packed so they can safely be rolled or trucked. A. E. R. W.

General principles of drying and firing. Carl Jacob. (Trans. by W. L. Shearer and A. W. Holtzmann) *The Ceramist*, **7** [2], 63–80 (1925).—By drying is understood the expulsion of the water of plasticity which is present after shaping. J. discusses the effect of the nature and prepn. of the clay and the shape of the product on the danger of cracking and warping. Uniform working is one of the most important factors in minimizing cracking and warping. The effect of temp. and moisture content on the drying rate and different types of driers is discussed. J. outlines the different stages of firing and discusses the firing behaviour of typical clays and the properties and colors of the finished products. He outlines the proper procedure in glazing. A.E.R.W.

Opinions of a factory man on ceramic education. Charles W. Hill. *The Ceramist*, **7** [2], 94–111, (1925).—H. outlines briefly the various types of work which may engage the services of men trained in ceramics, under the headings (1) research, (2) laboratory, (3) factory control, (4) factory management and (5) sales. He then makes an anal. of the courses in ceramics which are now offered and discusses each subject in detail. H. discusses how the ceramic courses might be improved, especially in regard to giving a knowledge of the properties of industrial products, and points out ways in which the manufacturers can coöperate with the ceramic schools. A. E. R. W.

Handling of barrels and casks of pottery en route. C. M. Bonnell, Jr. *Ceramist*, **7** [3], 150–65 (1925).—The Freight Container Bureau, as well as several other organizations, is endeavoring to coördinate the interests of shippers and packers by developing facts relating to the transportation and packing of particular commodities and then establishing correct procedures. B. discusses the relative merits of loading pottery casks on end and on bilge. Arrangements should be made to keep casks from jamming against freight car doors. Many large carriers are using impact recorders to secure information as to the shocks that occur en route. A. E. R. W.

Depreciation, obsolescence, depletion. G. W. Greenwood. *Brick and Clay Rec.*, **67** [13], 935–36 (1926).—G. discusses method for figuring depreciation, repairs and so forth. R. E. G.

Chromite from Mont Djeti, near Atakpame, Togo. M. H. ARSANDAUX. *Bull. soc. franç. mineral*, **48**, 70–6 (1925).—The high Al and Mg content places this mineral intermediate between spinel and chromite. (*C. A.*)

Experimental study on the transmission of heat by some building materials made at the University of Lausanne. DUMAS. *Bull. technique de la Suisse romande*, Nov. 10 and 24, 1923; *Génie civil*, **84**, 43–4 (1925).—Expts. made with walls electrically heated from within showed that a considerable rôle is played by moisture. Porous mat. when dry give much better insulation than more dense substances, but a wet porous wall conducts heat more strongly than a less porous wall does when dry. (*C. A.*)

PATENTS

Modeling clay. EARL E. SNOOK. U. S. 1,568,098, Jan. 5, 1926. A plastic compn. adapted to form a modeling clay comprising approx. 8 oz. of gelatine glue, 11½ oz. of water, 8 oz. of boiled linseed oil, 1 lb. of "titanox," 6 lbs. 1 oz .of bolted whiting, 3 oz. of chrome yellow and ½ oz. of methyl salicylate.

Removing suspended particles from materials forming viscous fusions. E. THOMSON. U. S. 1,559,203, Oct. 27. After fusing quartz or similar materials, the fusion is centrifuged to sep. suspended particles and then allowed to solidify so that the sepd. material can readily be sepd. mechanically from the solidified purified layer. (*C. A.*)

Bricks, pottery, etc. V. M. GOLDSCHMIDT and J. C. W. VAN KROGH. Brit. 232,943, April 25, 1924. In the manuf. of burnt or sintered clay products, the base mat. is mixed, before firing, with a substance which is richer in Fe, in such quantity as to effect an increase in the % of FeO compds. in the final product of 3–15%. About 1% of borax also may be added. A rapid firing of the mat. produces a relatively porous product and a slower burning product of greater solidity. (*C. A.*)

BOOK REVIEW

The Parthenon. Its science of forms. By ROBERT W. GARDNER. 20¼x14½, 35 pages, New York University Press, 1924. $15.00.

This book, by a practicing architect and lecturer on architecture at New York University, is a profoundly important and easily grasped contribution not only to architecture, but in reality to design in all the arts and crafts. He has discovered a geometric canon that discloses the underlying design of the Parthenon and the city and port of Athens as rebuilt after the Persian wars.

Mr. Gardner is wise in his presentation of the materials of his research. He writes with notable terseness, logical sequence and clarity. His facts are stated in the text and are demonstrated in the plates. Everything is omitted that is so obvious that explanations are unnecessary—such as his evident indebtedness to the original discoveries of the late Jay Hambidge, an acknowledgement that might well have been made with gracious courtesy. Such single minded concentration on the subject has produced a text that is classic in style. The lay-out and printing of the book by William E. Rudge are appropriately dignified and elegant.

Mr. Gardner's achievement, as we have already indicated, is the discovery of a canon of design—of a canon which unites the known predilection of the Greek mind for both balance and proportion within an application of elementary principles of Greek geometry. His nucleus is an area which he identifies with the Attic unit of land measure. This unit, a square, centered within the plan of the Parthenon, is expanded concentrically by successive repetitions of the same geometric method, by which constancy in the proportions of the form is always retained. So far as the writer is aware, Mr. Gardner has thus devised the most simple and logical way yet discovered of obtaining, with Greek

finesse, the highly important qualities of similarity or related proportions of forms, of logical and sequent interrelations, and of balance, all combined in a design of no matter what magnitude from diminutive size to projects of vastest scope.

His demonstration is the application of his canon to the Parthenon and the classic city and port of Athens, using the surveys of the Parthenon by Penrose, and the reconstructed maps of the Periclean city of Athens by Curtius and Kaupert, and of the port of the Piræus by Milchöfer and Kaupert. The diagonals across the cella of the Parthenon were sighted, he shows, on landmarks, towards the southwest on the Island of Stalida, outside the haven of the Piræus (this being Mr. Gardner's primary base line of commensurable stadia and Attic feet), and towards the northwest on Mount Aigaelcos. The medial axis of the Parthenon led direct to Mount Pausanius, and this line Mr. Gardner makes the perpendicular bisector of his geometric scheme, which he has drawn on the carefully measured plans and elevations of Penrose superposed on the maps of Curtius and Milchöfer reduced for the purpose to a commensurate scale. He makes a successful demonstration that his geometric series, which may well be called the *canon of Gardner*, produced by square and compass alone (not by a measuring stick) from a single unit, mark and define not only the design of the Parthenon itself in both plan and elevation, but the placing in plan of that entire vast architectural complex comprising the other buildings and monuments and the walls of the Acropolis, of the city of Athens and the port of the Piræus. Mr. Gardner has placed before the eyes of the modern world the evidences of a supreme realization of the teachings of Anaxagoras of Clazomenæ in the rebuilding of Athens by the men whom he had trained. The entire plan, Mr. Gardner discloses, was conceived as the expansion of a unit, and was ultimately carried out as planned. The demonstration may be considered conclusive. It is a great vision to which our eyes are opened.

The canon of Gardner works, and with a simplicity of operation that all who have availed themselves of Hambidge's Dynamic Symmetry will recognize and welcome. Both are, we believe, true applications of Greek geometry.

Although Mr. Gardner states that he is not attempting to formulate a method of design, he has done that very thing. He gives us a method that can aid us in the creation, not of Greek art, but of beautiful forms appropriate to current necessities. His canon can be used in a way that it has always been natural for designers to work, as an aid for the quick easy selection of proportions that look right. Analysis is left to the intellectually inclined. Arithmetic does not enter into his method. He is a practical architect writing for architects. But his method is of equal interest to sculptors, artist-painters and craftsmen. It has been a great handicap to the wider acceptance and use of Dynamic Symmetry that Mr. Hambidge wrote analytically, with arithmetical proof of his geometrical facts, his definite purpose having been to convince archaeologists. Only here and there were there artists who were willing to undertake the task of translating this analytical material into synthetic methods of applying Dynamic Symmetry to their individual problems of design. Those who did profited enormously by it, and gratefully acknowledge their indebtedness to Mr. Hambidge.

The method disclosed in Mr. Gardner's book may well have been the usual procedure of Hellenic design, but here we find the unit square developed and expanded into three types only: (1) squares on a binary ratio; (2) half-triglyph, metope, half-triglyph areas; and, (3) root-five rectangles. It seems highly probable therefore that Mr. Gardner has only disclosed a corner of the probable content of Greek art. We hope that he may continue his research until he may have discovered that which eluded Mr. Hambidge—a really important application to Hellenic architecture of the equilateral triangle, the half of which is the scalene right-angled triangle which Plato declared to be the most beautiful. Mr. Gardner's original method of developing the elevation concentrically

on the plan of the Parthenon makes more of the design elements immediately evident than any other presentation that we know. It intrigues us to hope that he may turn his attention to the Erectheum, which does not appear to have been developed from the same derived forms as the Parthenon. This temple has now been measured by Messrs. McKin, Mead and White as accurately, as we are told, as the Parthenon was surveyed by Penrose. It would be most desirable if their data were placed at Mr. Gardner's disposition.

The writer wishes that Mr. Gardner's "Technical Description of Detail Plates, I–IX" might each have been printed opposite the drawings they explain instead of as an integral part of the text. This would have saved the student much now necessary turning of large pages. Otherwise there is nothing but highest praise for this book that gives promise of marking a new epoch in art.

It is to be hoped that Mr. Gardner, or any other architect, may be given the opportunity of demonstrating to the public the results of this discovery in its application to some notable structure to be erected on this method of design. Entirely aside from the geometric aspect of this problem, there is a remorseless logic in the Greek method of superimposing their elevation and section on the ground plan of the building in their process of design as Mr. Gardner shows it. What disharmony of proportion in the remotest part could survive that simple but searching test? While invaluable to the designer, it is a cruel weapon to put into the hands of the critic who will watch the subsequent development of the art of design with a renewed zest.

By Wilford S. Conrow

Have You Any of These for Sale?

Transactions and Journals Out of Print

Volumes 2, 5, 8, 9, 10, 11, 12, 14, 18 and 19 of the *Transactions of the American Ceramic Society* are out of print. As we have received several requests for these numbers $5.00 will be paid for each copy on receipt in the Secretary's office.

The January and June, 1923 and the January, February, 1924 issues of the Journal are also out of print; 60 cents will be paid for each copy received by

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of the

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A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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Vol. 5 March, 1926 No. 3

EDITORIAL

KNOWLEDGE IS A MOSAIC

The extensive and varied program of papers and discussions for the Atlanta Meeting has brought to thought the small portion of the world's sum total of knowledge which each person can work over and how much larger portion of the world's knowledge each person unwittingly uses. We use the telephone, the automobile, the radio, and many other things, each of which was made possible by some one bringing together several bits of known facts and principles with which we, the beneficiaries, are not familiar. No man can know all the fundamental details of the equipment, methods and mixtures which he uses daily, yet there are individuals who found and proved the fundamentals and others who made applications of these fundamentals involved with the result that we are all the beneficiaries.

The total sum of the world's knowledge may be likened unto a great, useful mosaic, each piece of which was provided by an individual. Very few have the good fortune to discover and make known bits of basic knowledge but each person has the opportunity, the ability, and the duty to work over that limited portion of this useful mosaic to which by talent he has been assigned. What each person contributes

to this mosaic construction is minute compared to the whole and yet each small contribution determines the usefulness of the finished product.

The bits of fundamental knowledge used in this grand mosaic of knowledge are like unto the Biblical five loaves, the more served by it the larger is its capacity to serve with fragments remaining.

There is no record, nor support in the logic, that benefit can be derived from withholding data from this mosaic of knowledge. Manufacturing information, guarded only against the cunningness of unscrupulous competitors, will manifold its benefits when made generally known. The open door and frank exchange give access to information. One person can have the benefit of the experience and studies of many if he will invite a fair exchange.

It is not theory, nor an idealistic dream, that several manufacturers of like ware, each competing in the same market, can, with profit to each, have a very intimate exchange of manufacturing information on plant methods, equipment, materials and mixtures. Exchange of notes and plant inspections by the superintendents in two diverse groups known by the writer has resulted in production economies, lower losses, and better product quality without in the least affecting their relations in the market.

No one can work alone on this mosaic. Groups as well as individuals are dependent on one another. This mutual dependency applies to firms in the same business and to the trade associations. "Coördination of effort" cannot be a hackneyed term, although it is a much-used phrasing of an ideal.

The ceramic portion of this intricate scheme of knowledge is not what modern manufacturers in England or France or America have made of it, but it stands today the net result of centuries of work of countless ceramists the world over, each adding his bit.

Until lately there was no coördination in effort but today in each of the industrial nations there are societies and associations representing a latent, even though not a frankly practiced desire to coördinate each person, each firm and each associated group in team work to make the ceramic portion of the world's great design of knowledge most substantial and useful. Serving one's self by this coördinated association of effort serves mankind in general through the vast industrial and social activities in which ceramic products are essential. The effectiveness of the whole project in benefitting mankind is dependent on the faithfulness of each ceramist in contributing his bit of knowledge to this mosaic of knowledge.

PAPERS AND DISCUSSIONS

INDUSTRIAL POTTER CRAFTSMEN[1]

By Edmund deF. Curtis

The questions that have been raised at this Meeting "How may we get more trained artists into the industry" and "How can it be made more possible for the potter craftsman to earn a decent living" are both of very great importance to the artistic future of the industry.

Ever since prehistoric days, when man first discovered that clay would harden under the influence of heat; that it could be shaped and colored and devoted to purposes of use and of decoration, individual potters have carried the torch from one kiln to another down through the ages. And I fully believe that the artistic progress of the product of the kiln, from a shapeless dish to a pot fit to stand with the jeweled treasures of an emperor, has been due to the work of the potter craftsman. Factories have sprung up often to supply the demand for some particular ware, but the craftsman created the necessity for the factory and we must look to the modern craftsman to influence the public taste so that they will demand better things from the factory.

We must get the trained artists into the industry by training them as craftsmen and we must do this so that they will be able to exist until, by some happy combination of public demand for better work and of factory consciousness that art and the machine can be profitably combined, the industry as a whole begins to absorb the new ceramic artist.

If there are not enough craftsmen working to have any effect on the average standard of quality, the responsibility for that condition shifts to this Society. And if the Society as a whole is absorbed in engineering and industrial problems, which I believe to be a fact, that responsibility rests with the Art Division.

1. Necessary Artistic to Technical Training

The potter craftsman should have his art training, cast drawing, modeling, theory of design, theory of color, lettering and perspective. He should have sufficient technical training to be able to build his own kilns and repair them, to form the clay, to make molds, to build, cast and throw pottery forms; to calculate, mix and apply his own glazes; to load and fire his kilns; and to be familiar with all the many decorative processes. He must know how to run his shop at a profit and he must realize that he is undertaking work that calls for production.

In addition to this he must be able to meet architects and interior decorators on their own ground. It sounds a little like an encyclopedia

[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb. 1926. (Art Division). Recd. Jan. 5, 1926.

but I am sure he could cover the ground in two years. If in addition to this we could establish coöperative kilns where he could get the actual shop practice so essential to pottery work he would be far better equipped to tackle his job than the average potter is today.

2. The Small Shop The craftsman must have tools and a place to work and very few of them can afford the present outfit offered by the machinery manufacturers; but he could afford a few hundred dollars, put into simple tools that have been tried out and found to do the work. We must work out a small shop large enough to be more than a toy and cheap enough to allow the average student to tackle it with blue prints and costs and specification. With this we must publish a definite standard method of working from which he may deviate according to his ability to experiment but on which he may fall back in time of excessive loss; and we must break him of the habit of spending weeks and months "discovering" something that is "old stuff" to the man in the next town.

3. Chart the Field for Opportunity If you will walk through any large city and count the number of stores filled with lamps, bowls, and vases, mostly trash, you will feel reassured that there is room for a good many workers provided that they have the proper training and shop, and can at least approach the commercial price. But it is not necessary for us all to confine our abilities to that type of work. There are overmantel panels, hearth tile, fireplace facings, decorative tile, panels for exterior work, porch tile, portrait medallions, smaller pieces of sculpture executed in terra cotta, garden furniture of cement with tile ornamentation, electrical fixtures, large jars for gardens, special colors for pool tile, fountain heads of original design and many more. These products are as much for the craftsman as the factory. Why should a man pay one thousand dollars for a painting and hang it in a room with mantel No. 763 green 3x3? Can he not be educated to the fact that there is design and technique in the mantel just as there is in the painting? The investigation of this side of the problem should include illustrations of good work of the different types with costs and selling prices so that the student can specialize in the work that appeals to him according to the volume that he is prepared to put out.

4. Reprints All through the *Transactions* and *Journals* of this SOCIETY there are articles tremendously valuable to the craftsman and these ought to be gathered and reprinted by the Art Section. There are formulas, tables, results of experimental work on colors, textures, and bodies that would represent years of work for the individual, if, indeed, any individual would be capable of the research involved. These articles, perhaps condensed, ought to be part of his equipment.

5. Publicity One of our hardest jobs will be to educate the public so that it will really appreciate spontaneous original work, so that it will have a real knowledge of values and at the same time will be broken of the idea that hand work in itself is of value and that hand work necessarily means crude work.

A traveling exhibition each year and a few competitions to bring out the best work would do a good deal toward this result.

6. Circulating Library A library of books and magazine articles of interest and value to the craftsman could be gathered at some central point and for a small fee to cover mailing charges and clerical work could be made available to many. Each of us probably has a book or two he would contribute and perhaps a few dollars, whereas it is out of the question for us to own all the expensive editions. The outlook of the craftsman must be broadened and I know of no more stimulating influence than to have access to a good library.

I believe that if a committee of five started this program it would roll on by itself and in time would accomplish much that the lone craftsman of today can only dream about.

The report of the Committee would be referred to Miss Sheerer, who would ascertain the cost in money of putting it through and she would advise the Committee who would proceed to raise the necessary funds. This is an ambitious program, but if we really want to raise the standard of Ceramic Art in the United States to a level with that of any country or any period we must accept the fact that it is a long hard job and lay our plans accordingly.

CONESTOGA POTTERY
WAYNE, PA.

COÖRDINATION OF ART, SCIENCE AND PRACTICE[1]

BY M. ELIZABETH COOK

In considering this subject one humbly realizes that not art alone is long, but also science, and one little life-time all too brief in which to achieve in practice, the perfection of such coördination. Happily, though, we are on the way in all our industries whose development is dependent upon the alliance of art and science to achieve success commercially.

We who know the intriguing charm of clay, either in the laboratory as a mineral, or in the studio as the ideal medium in which to design, will agree that in no other natural product of this earth has been recorded so fully and beautifully the history of mankind.

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[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb. 1926. (Art Division). Received December 15, 1925.

In the great periods of this history, the golden ages of creative effort, science and art were hand in hand; and men gave free expression to the creative impulse, that resulted in the rare and precious collections that fill our museums. We of America are just emerging from a dark age of doubt and timidity, where we have groped a bit to find ourselves in constructive art; it has been much easier to buy with dollars the beauty of other lands, than to create one's own.

Then too, we have been too absorbed, mining, analyzing, compounding this wonderful thing beloved of artists and craftsmen of the ages, and in perfecting machinery and kilns to put it into completed form, to consider just what shape that form should take, or how it shall be decorated.

A high degree of scientific knowledge of ceramics has been reached; how utilize it? Have we the vision of American clays put into masterly forms of beauty by American hands, or are we to depend still upon the skillfully trained artists of other lands.

They have shown us the road to beauty as revealed to them in their own country, and recorded in their products. We have the fundamentals but must learn to apply them.

There is no war between art and science, in fact they are interdependent. Any creative effort of man, to be a work of art, must be fundamentally constructed on scientific laws and vice versa. To give one illustration (out of many possible ones) the propellor of an aeroplane must be constructed of the finest wood, most beautifully finished; the more subtile and lovely the curves of the blades, the more nearly they conform to the laws of beauty, the more scientifically efficient they become, and the better attuned to the waves of ether, as is the violin to the waves of sound.

"The line of beauty is also the line of strength" in clay products. Full recognition is granted the scientific ceramist; but have we recognized fully the wider opportunity that would be his if his scientific training could be given plus a knowledge of proportion and symmetry, in construction of clay products; the history of art in ceramics, of design, the relation of color to form?

Without doubt the student having only abstract scientific knowledge of the possibilities in clay is not prepared to make practical use of his scientific training. Contrary to the generally accepted idea that the artist must of necessity be an impractical dreamer, he is, as a matter of fact, more practical than the scientist; the latter can make an abstract statement of certain facts, but the artist potter can visibly and concretely prove his facts, in three dimensions.

The ideal, for the ceramist, then, is to equip himself with the dual knowledge of the art and science of clay and seek the field in which to "practice."

We are awake at last, in this country, to the deadening menace of the machine, if we continue making man merely the extension of the machine in industry, and quantity production our god. The call has come, in all arts as in industry, for the creative, reflective spirit that alone can give the quality to our products that our civilization, our national pride, demands.

Are American clay products to keep pace with, or better still, lead the clay production of the world? If so, where are our creative workers to be trained? Are we as a country enormously rich in this the greatest medium for artistic and scientific research offering opportunities for practical constructive training in the art as well as the science of ceramics?

In other industries where art and science are allied, constructive, creative courses of training are given the students, and a knowledge of the practical demands upon him.

Millions are being spent annually in this country for collections of porcelain, china, terra cottas, every form of clay products, for the great museums, accessible only to the few students able to go to the art centers.

Is it feasible to secure travelling exhibitions of ceramic masterpieces, to be shown at the ceramic engineering colleges, if possible have the collection fully explained to the students on its historic and artistic value, with data on type of body, glaze, decoration, etc?

The American Federation of Arts has arranged travelling exhibitions that are sent to every art school in the country, small or large, if so desired, for the education of the students in the appreciation of painting, sculpture, design, etching, all creative arts.

The ceramic student having opportunity to study a representative exhibition of the world's masterpieces in clay products would be inspired to further efforts to round out his training. The beauty and possibilities in the many simple methods of decoration on historic pieces would suggest opportunities for original design in such method; the charm of slip painting, underglaze painting on the bisque or green body, etc.

The beautiful forms with the color and design so well adapted to them would be an invaluable assistance. The educational value to the student who could supplement a course in applied design in clay, with careful study of such exhibitions, can not be estimated; it is one thing to be told that such and such laws of symmetry and proportion control designing in pottery in terra cotta, but to see actual demonstration of these laws spurs the creative thought.

Finally, the designer in clay is not designing in two dimensions (as for textiles or wall paper) but in three, if he designs pottery and terra

cotta. A finished clay product, though scientifically good, will not be a thing of beauty or of much commercial value if not well proportioned and graceful in line. If decorated in relief, or painting, the design and color of such decoration must be adapted to the form.

Art is that skill which fits a chosen medium to its purpose and helps to make the things we need, things of beauty, records of the days in which we live and of our scientific achievements beautifully told.

1550 Clifton Ave.,
Columbus, Ohio.

A "REACTION" TO A VISIT TO THE CERAMIC SECTIONS OF THE INTERNATIONAL EXPOSITION AT PARIS, 1925[1]

By Mary G. Sheerer[2]

Coöperation of Science and Art

If I were to endeavor to put into one sentence my greatest reaction to the Paris Exposition, it would relate to the unusual coöperation between the science and art, and the industry and art of ceramics, as shown by the products of the Royal Manufacture, and Bing and Grondahl's, at Copenhagen, Denmark, and the Orrefors Engraved Glass at Stockholm, Sweden.

As far as I can tell, through the work of these factories, the three phases of ceramics are equally balanced, certainly in the two porcelain factories, which I happen to know more about through literature and through correspondence.

Both factories show porcelain, earthenware, and *grès* of excellent quality, also quantity-produced table ware, ornaments, and individual pieces, all designed by the best ceramic artists. These special artists are widely advertised and are a great asset to the factory. The signature of the artist on the pieces increases their value; it makes their value, in fact. Added to this are the arts of industry, of arrangement, of advertising, of selling and the art of the machine; all seem to be equally underscored by these factories.

Coöperation of Art and Production

The great cry since the war, as we hear on every side, is that the barriers between nations must be broken down if progress is to be looked for. In these two factories the barriers between art and industry, barriers to progress, seemed to have been wiped out.

With the facilities of a large plant, scientifically run, to provide the different kinds of body and glaze, the artist seems to have full choice of

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[1] Presented at the Annual Meeting, American Ceramic Society, Atlanta, Ga., Feb. 1926. (Art Division). Recd. Jan. 5, 1926.

[2] Delegate with the United States Commission.

material with which to best express his form or decoration. From the carefully prepared fine-textured porcelain clays which call for a sophisticated handling, he can swing to the coarser, more plastic stoneware clays and the glazes which go with them, or to the many colors which faience allows.

Each artist is characterized by certain kinds of work, a free expression of himself. He stamps the piece; the piece or the factory does not stamp him. I have never seen such diversity of style and of material from one factory, and they have proved that individuality and beauty are highly practical.

In our American factories, if an artist is employed at all, he must follow certain styles; styles, usually copied from England or France; anything but American. I know that anything else is considered impractical, but when the American public and the factories realize that we are very much criticized and, indeed, are not on the ceramic map, because we are copyists, it would seem that the time had come to take action to bring up our product artistically as well as technically.

Art Appreciation on Increase

Our people are rapidly becoming educated in other of the household arts, and are recognizing good designs whether foreign or domestic. The number of good art schools and the designers they are turning out could have no other result. That we are further behind in the ceramic art than in many others is evidenced by the fact that the museums which are interesting themselves in industrial art and which give exhibitions of American factory-made products, invite only a few factories to participate.

There are faint signs, however, of a desire to raise the standard of our household ceramics. The fact that ceramic courses are being introduced in some high schools and more colleges is one of them. It is true that drawing and design are too often not included but many of us are asking the reason, where formerly there was no question. The formulation of a definite course by an art school to prepare decorators for the ceramic industry, the good work being done by the public schools, the most important move of all, the activities of the Art Division of the AMERICAN CERAMIC SOCIETY, and the increasing interest being shown the craftsman and his work are other of these "signs."

In France it is the ceramic artist or craftsman who is taking the lead; chief among them are Decoeur, Mayodon, and Lenoble. One sees echoes of their work, which is ceramic art in its purity, their influence, in the factory-made, decorative pieces. I was impressed by the exhibition of the Primavera factory, which is connected with Le Printemps, a large department store in Paris and by that of the Gallery Lafayette. The cheap, poor quality, Japanese imitation of the worst types of

European pottery and porcelain were missing. In its stead, they were showing a reflection of modern thought, modern art in all the household wares.

Art Trend to Unconventional

Speaking of modern art, which was the keynote of the Exposition, I, personally, feel that the real import of it is a desire to get away from the conventions of the past and to begin to think anew in terms of our own times, terms dictated largely and most recently by the very general use of concrete for building.

If we are now going through a mechanical, scientific age as shown in the right-angled, triangled, straightened lines of our new architecture in New York and Paris; if modernist pictures and decorations are reflecting the same thought, and if ceramic form and decoration follow suit, does it not seem more honest to glorify the straight line as the Exposition does, than to apathetically fall back on the thought of other times and recline too long and too entirely on the curves of precedent?

Our French hosts mentioned in their opening address that we were "infatuated with the classical"; that we could not see beauty in anything else. They claim that the modern use of the straight line, with the simplification and abstraction of form and design which it employs, has been used by them for thirty years and is no longer an experiment, that choice modern sculpture, furniture and architecture hold their own with recognized work of the past, and that they are not out of place among the most highly prized collections of antique art.

An author in *Illustration* makes the point that "modernism has been slowly evolving for thirty years and that it is a product of ancient art adapted to modern needs."

Let me also quote from an article about Bertram Goodhue, who was given the gold medal of the American Institute of Architects last year. "His rebellion against classical forms was not a criticism of them as solutions, but an expression of impatience with the aridity and falseness of mere copying."

The modern movement is not as marked in the ceramic household arts as in architecture, for example, but there is a departure from the small, painstaking, literal form and decoration to the much simpler, more abstract and more imaginative rendering of animal and figure decorative pieces and of table ware, with much more brilliant color. There is little "apologetic drawing, design and color"; directness, simplicity run all down the line.

It was interesting to contrast the work of the modern men with that of the Sèvres National Factory, the latter of which I visited twenty-five years ago. At the factory and at the two pavillions of Sèvres, mastery and perfection of technique and the accomplishment of un-

heard of ceramic feats, seemed to be the objective rather than a desire to create. The factories at Limoges, on the contrary, are animated by a fresh, live spirit and are showing numerous new effects of design and color. The designs of Goupy are specially delightful.

I have read recently in one of the Chicago papers that the net profits of the exposition amounted to $4,000,000 which will be used for a permanent school of decorative arts in Paris.

NEWCOMB COLLEGE
NEW ORLEANS, LA.

REPORT OF THE CERAMICS OF THE INTERNATIONAL EXPOSITION AT PARIS, 1925[1]

BY ADELAIDE ALSOP ROBINEAU[2]

Possibly our public is not educated to appreciate art, *per se*, looks first for utility and second and last to follow the fashion. Our potters have not that *amour propre* of the Frenchman and Englishman that makes them demand that their country lead the fashion. One remarks first and foremost at the Exposition that almost every potter of any ability is being employed to direct or design for some manufacture of ceramics.

Since the war France has awakened to the fact that in her artists and art school she has an inexhaustible source of inspiration for her manufacturers which can bring back to the impoverished country the needed wealth in competition with other countries. French manufacturers are employing artists in numbers and trying out the public.

American manufacturers make the mistake of being over-conservative and keep a deadly level, with so few exceptions that one wonders if those few were not lapses in watchfulness.

The points worthy of consideration by American ceramic industries and individual potters class themselves in my mind under the following heads:

1.—Ceramics used sculpturally and architecturally
2.—Ceramic vases for use and cabinet
3.—Ceramic figurines and novelties
4.—Ceramic tableware

The ceramic exhibits both of France and Denmark are full of inspirational value in design, materials, and technique of execution. As much cannot be said of the tableware, although there are some table services which show rather a "searching" for something new and different. But in the majority of cases the designs have not "arrived."

[1] Presented at the Annual Meeting, AMERICAN CERAMIC SOCIETY, Atlanta, Ga., Feb. 1926. (Art Division). Received January, 1926.

[2] Delegate with U. S. Commission.

The "Tranquebar" of Copenhagen and some of the other blue and white services of the Danish manufacturers are very attractive but can hardly be said to have the lasting and universal qualities of the original Copenhagen pattern, nor of the old "onion" Dresden pattern

The cream white ware of Goupy, with modelled designs, is an interesting development of the cream Wedgwood, and quite worth while, especially in the forms of platters and other large dishes.

Some very interesting and attractive services are shown by Jean Luce, new ideas in handles. There is a tendency to bigness and simplicity which is refreshing, both in design and color. Color combinations on rims of plates, etc., with decorative medallions, are quite prevalent. The futuristic influence is much in evidence, but seems to be developing into something saner and yet quite new and attractive. Here and there one sees attempts at a development of the peasant style of brush work in decoration, which is not only very effective in color and refreshing in its feeling of freedom, but also appears to take the popular fancy.

Especially to be noted is the widespread interest in figurines and grotesque forms, both human and animal motifs for ornament and decoration for table, mantel or cabinet, from the more or less naturalistic Royal Copenhagen and Bing and Grondahl to the futuristic things of Le Bourgeois and of the Primavera Studio (Magasins du Printemps), of Chevallier (Galleries Lafayette), Luyritz, De Canto, Weillemir, (Fau and Guillard), and the quaint and fantastic forms for chessmen, candy boxes, night lamps, etc., shown by Maurice Baille, Jean Lusca and others. A great deal of real originality and artistic merit attaches to many of these, especially in the large pieces which resemble more actual sculpture, as well as in the *grès* of Gauguin, Knud Kyhn, and Siegfried Wagner.

American architecture and interior decoration would gain more life, if, as in Europe, we used more of the original thought and joyful sculptural detail which gives such delightful surprises at every turn in old European architecture, and of which there seems to be a renascence in the smaller things of today.

The Danish section had the most inspiring exhibit because of the greater initiative shown, not only in types of design and decoration, but in the use of material. Here is perhaps best illustrated the value of employing really worthwhile artists, for almost all of the big individual artists are employed in the works of the Royal Copenhagen Manufacture and of Bing and Grondahl, and beyond a doubt these firms are today leading the world in the production of art ceramics in quantities. The individual potters who direct the different lines of work in these potteries—and there are many different lines—have a force and freedom of thought and execution not often found in the exhibits of other

countries, and assuredly nowhere else is found so vast an aggregation of talent.

The point especially to be dwelt upon is that *they make it pay*. The public appreciates new things if they are really beautiful or novel. If people still buy the wearisome old ideas, it is because they must, because the newer, better things are not made in sufficient quantity to appeal to their purses.

Here every piece has the beauty or interest and finish of an individual piece, and the fact that the individual artist who designs them is also a maker of unique pieces of great monetary value adds much to the eagerness of the public to buy examples of his or her work which the large firms offer.

Jais Nielsen, perhaps the most original of all the Danish potters, designs and executes for the Royal Copenhagen Manufacture vases in celadon of delicate finish and figures in *grès*, massive and free in technique. His individual work is a crude looking faience or yellowish stoneware with free brush work decoration and colors reminiscent of the early Christian or Coptic, the subjects biblical or Byzantine. His crudely modelled figures of men and animals, surmounting his large jars or forming handles, are stimulating to the imagination. His drawings are incised in the main lines with a strong, sweeping stroke. He is a master of technique worth studying in every way.

The greatest outstanding figure, however, is that of Jean Gauguin, son of the French painter. He is a sculptor, but in a plastic material. For him the manufactory has experimented in stoneware and in porcelain until they have achieved a mixture which enables Gauguin to execute massive and solid forms that withstand the extreme heat without breakage.

His animals and figures have a strength, boldness, freedom, combined with a rugged fantasy and grotesquerie, that make them unique in the field of ceramics. Whatever inspiration they show from outside is rather Oriental. His grotesque bulls and dogs are full of "violent and pagan life."

Besides the works of the already mentioned artists, the Royal Manufacture and that of Bing and Grondahl show unique works of artists who do not exhibit elsewhere and owe their development to the advantages of pastes and glazes offered for their use in the manufactories and to the opportunities offered to them for experimentation.

Turning to the French exhibits, we find more of a clinging to old traditions of ceramic method, but at the same time many interesting, artistic and worthwhile developments, especially in the more popularly priced objects, which in a way are more important for disseminating a cultivated art taste among the masses. We find here that, while not

so many really prominent artists are employed in one manufactory, every manufactory of art pottery, and there are many of them, employs one or more artists of note.

Thus the firm of Fau and Guillard employs three sculptors of no mean merit, Wuilleumier, Leyritz, and de Canto, who design and execute the models for figurines, masks and architectural faience and stoneware, very modern in feeling, fine in conception, simple in execution and restrained in manner of decoration.

As compared with the Copenhagen Royal Manufacture or Bing and Grondahl, the National Manufacture of Sèvres employs probably as many decorators, but there seems to be a decided lack of individuality and no one name stands out except that of Paton who has designed the architectural *grès* for the Sèvres Pavillion. This Pavillion, apart from the annoyance it causes by forcing the visitors to go around an obstacle which they cannot surmount, as it stands in the center of the avenue leading to the Pont Alexandre, is really simple and dignified in conception, with many interesting features in the interior, though outwardly it resembles a mausoleum in its monumental *grès*, unrelieved by color.

Basins of water occupy the four corners of the court, the ends of which are flanked by a low rim of tile and massive grotesque animals by Le Bourgeois. There is one note of porcelain in the margins of the basins and in four large vases of deep turquoise blue which are reflected in the water.

A new feature at Sèvres are the table garnitures in stanniferous faience with polychrome decoration. The figurines modelled by Mlle. Henvelmans are very modern in treatment, simple in mass and line and very attractive. The figurines by Gebleus and Gauvenet are also very modern, intriguing in the overglaze decorative treatment of draperies. The vases exhibit the same tendency to over-decoration so frequently seen in the products of the Sèvres Manufacture, even those which are decorated in brush work; this brush work has not the freedom of the Danish work and resembles rather the old Italian decorative painting on faience.

The Pavillion Rouard contains the work of almost all the prominent individual French potters, some of whom also have an individual commercial output. The ceramics of Mayodon are perhaps the most notable from the point of view of a new type of technique and of original thought. Many people are intrigued by the fine tracery of gold, indefinitely glinting through.

A most interesting development is the Atelier Primavera, a ceramic studio in connection with the great department store of Le Printemps. The output is essentially modernistic, interesting, decorative, really

artistic. That a thoroughly commercial store should be willing to spend so much on absolutely new ceramics, extreme in type, argues well and should encourage our own manufacturers to try to get out of their ruts.

The Atelier Primavera employs several different potteries and individual artists. The pottery of Sainte Radegonde devotes itself especially to figurines and vases designed and executed in an extreme futuristic manner. Several designers are employed and the models executed by the sculptor Chassains and others, and glazed with a cream white glaze, with occasional treatment of parts in black. The subjects are usually groups of figures or single birds or animals on oblong square bases with flat sides, modelled in planes and angles similar to the technique used by Le Bourgeois. They are used as table ornaments in libraries, on mantels, etc., and have a charming quaintness. The main trouble is that less clever artists are likely to attempt to follow the vogue of this new type and so destroy its value.

The Galleries Lafayette, another department store, have also a ceramic atelier under the management of Maurice Dufresne and employ several artist decorators. The work is not so unusual but is extremely good in design and form. The sculptor Chevallier makes for the Galleries Lafayette figurines on the order of those made for the Atelier Primavera, decorated with touches of scarlet and black.

Jules Henriot and Mehant are developing the old peasant ware of Quimper, introducing new motifs and designs painted in the peasant style; an interesting experiment, but in danger of becoming too sophisticated in the attempt to be naïve.

The Spanish Pavillion exemplifies the architectural use of ceramics very strikingly. All windows are of stained glass, lending a mysterious allure to the interior court, the center of which is occupied by a ceramic fountain, surrounded by a tiled floor. The walls have a deep frieze of tiles in typical Spanish coloring and designs. Large vases are used to emphasize the important points. Without the building, tiled and sculptured wall fountains on either side of the entrance and pillars surmounted by grotesque figures and large urns make a tie with the crouching animals on the grass plot around the building. The wall fountains are combined in a most harmonious way with the stained glass windows above, all sunken in and held together by an arch of interesting, stepped form, which is used throughout the building.

Within the building is a large and interesting exhibit of the ceramics of Zuloaga, cousin of the painter. Typically Spanish in design and coloring, rich and profusely decorated with gold in many instances, but varied in type, from a peasant-like effect, naïvely drawn, and executed in stanniferous enamels on a terra cotta bisque, to the medieval

coffers with borders of saints in flat enamels, with incised brown outlines on a metallic ground.

The main criticism, and that is a serious one, is that the materials used are of so low a fire that many of the floor tile in the court, after the usage of a few months only, are worn and chipped in places, but the ware itself is perfectly in keeping with the surroundings.

Here and there, in the Swedish, Czechoslovakian, and other exhibits are to be found more or less interesting ceramics, but, like the British exhibit, they have little that is new and inspirational.

An outstanding feature of the Paris Exposition was the increasing use of ceramics, architecturally, both for interior and exterior construction, as well as for decoration, especially the use of glass for really large and important works, such as facings of walls, concealed lighting effects, windows, panels, cornices, pillars and fountains. Of the ceramics used architecturally, the stoneware pavillion of the Sèvres Manufacture, the pavillion of Rene Lalique and his glass fountain before the Cour des Metiers, the sunken garden in gilded porcelain mosaic, were perhaps the most notable examples, though everywhere one found the use of one or more of these materials in one way or another not in a dilettante way, but seriously; tiled bath rooms, dining rooms, courts, walls, with lighting concealed by the use of porcelain as well as semi-opaque glass, and even stoneware; dining room tables in glass, the designs showing in relief from underneath, with center fountains displaying colored lightings. The pavillion of Lalique and some of the interiors of the Sèvres pavillion demonstrated that glass could no longer be considered as too fragile for building purposes, columns, cornices, panels, even foundation blocks or pedestals.

The point which should be of greatest interest to our manufacturers is that, everywhere, the best artists and designers are being employed, not only to design and execute models to be reproduced industrially, but to superintend the output and try out new ideas. The unfortunate aspect of our industrial art is that the manufacturer is unwilling to put out anything essentially new, to risk having any new design left a dead weight on his hands. He will not take a chance in order to have the credit and advertisement, of doing something "forward looking" and distinctive. Foreign manufacturers have on the whole this thing to their credit: they are willing to put themselves in the hands of their artists, and evidently they make it worth the while, for their leading artists to build up the reputation of the firm.

SYRACUSE, N. Y.

ACTIVITIES OF THE SOCIETY

OFFICERS FOR 1926-27

The American Ceramic Society

R. L. Clare, President
B. Mifflin Hood, Vice President
H. B. Henderson, Treasurer
R. C. Purdy, General Secretary

Members of the Board of Trustees: P. E. Cox, Art; R. R. Danielson, Enamel; J. C. Hostetter, Glass; C. Forrest Tefft, Heavy Clay Products; E. C. Hill, Terra Cotta; A. V. Bleininger, White Ware; E. W. Tillotson and R. D. Landrum.

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Secy., R. F. Sherwood, Pass and Seymour, Inc., Solvay, N. Y.

B. Mifflin Hood[1], Our Vice President

Benjamin Mifflin Hood, one of the South's largest manufacturers of clay products, was born in Cambridge, Dorchester County, Maryland in 1877. He attended the schools of Queen Anne County, the Boys' High School of Philadelphia and afterward took courses at Drexel Institute, the Univerity of Pennsylvania, Johns Hopkins University, and the University of Illinois.

Mr. Hood came to Georgia in 1903 and engaged in the manufacture of brick. A few years later he threw himself into the campaign which ended the convict lease system in Georgia and freed the industrial worker from competition with convict labor. His business grew rapidly. Equipped with scientific knowledge, Mr. Hood realized the immense importance of the shale deposits of Georgia and for years has devoted a large share of his attention to their development. He served as Chairman of the Committee to promote and raise funds for the new Ceramic School at Georgia School of Technology.

During the world war, Mr. Hood equipped twenty-three plants to make vitrified stoneware used in the manufacture of chemicals and high explosives, and produced 150,000,000 pieces for the United States and Canadian governments.

Mr. Hood has been consistently interested in the industrial developments of Georgia and the South and active in many projects along that line.

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[1] For photograph of Mr. Hood, see *Bull. Amer. Ceram. Soc.*, **5** [1], 53 (1926).

THE ANNUAL MEETING OF THE AMERICAN CERAMIC SOCIETY

The twenty-eighth Annual Meeting of the AMERICAN CERAMIC SOCIETY held in Atlanta, Macon, Gordon, and McIntyre, Georgia during the week of February 8, established new standards, excelling previous meetings in every respect. The registered delegates numbered 550 and the ladies attending numbered 185. In addition there were several locals who registered as guests and hosts. The technical program was unusually rich in fundamental and applied information, and noteworthy was the larger number of program participants than at any previous meeting. The exhibits were more extensive, more numerous and of higher quality than heretofore. The exhibit of art and artistic utility ceramic ware by the Art Division was most excellent in quality, variety and in the manner of its display. It was more pretentious than any previously attempted by the Art Division.

The distinguished guests, (1) Hon. Frank West, president of the Ceramic Society of England, (2) Robert W. Gardner, New York Society of Craftsmen, and (3) Dr. Charles H. Herty, president of Synthetic Organic Chemical Manufacturers Association added to the tone and real value of the occasion.

The social side of this Meeting divides naturally according to cities. In Atlanta, the "cut up" at the Woman's Club of Atlanta, the banquet Wednesday evening, the motor trip to Stone Mountain preceded by a complimentary luncheon and a continuous round of entertainment for the ladies were the social contributions by the citizenry of Atlanta. "Cousin" Fred Houser for the men and Mrs. Norman Sharp for the women of Atlanta seemed to have unlimited resources at their command to meet every opportunity to entertain and serve; and right royally they did. Dr. M. L. Brittain was ever alert to see that the score on score of local workers and entertainers did their utmost in their assigned tasks with the result that the delegates realized that their every desire was being satisfied. To feed and transport in private motor cars to Stone Mountain 16 miles from Atlanta over 500 persons, returning them to the ceramic special train or to hotel as desired, all within the time limit of three hours was a large task accomplished with ease and made delightful. To the civic clubs of Atlanta there is a deep obligation from every person who attended this Stone Mountain party.

The next host was the Central of Georgia Railway. President L. A. Downs and Industrial Agent James Milton Mallory and the several officials of C. G. R. gave facilities and personal attention throughout the week but it was Thursday noon on their ceramic special train which conveyed 300 delegates to Macon that their real hospitality was in evidence. At the price of a one-way fare plus twenty-five cents they furnished a special train for use of the party from Thursday noon to Friday night, taking the party to Macon on Thursday and to McIntyre and Gordon and returning to Macon on Friday, with a ticket coupon for return fare to Atlanta on Saturday.

But not alone in connection with this ceramic special train were the delegates recipients of favors by the Central of Georgia Railway. For three years the officials of this road labored with the Georgians and with this SOCIETY, not with the usual propaganda, but with costly fundamental and applied investigations of the industrial possibilities of Georgian clays. These investigations led to establishing in Gordon a most up-to-date and unique facebrick factory, a refining which resulted in larger sales of filler clay for paper, rubber and other products, and in the finding of a clay that will rival any for white vitreous china. Through these investigations, and by several State and National exhibits, that painstaking and iron-willed gentleman "Jim Mallory" made the home folks want to show with what Nature had blessed them in materials, climate, labor and market. He caused many others than those who at-

tended this Meeting to desire to see the materials, the people, the locations, and the climate which could inspire so great a vision. And when gathered at the appointed places for consideration of serious ceramic questions, to view exhibits, or to enjoy a social hour, the pleasant graciousness of Jim Mallory was always helping spiritually and materially. What a host the Central of Georgia was on all occasions no one will fully realize unless he wonders why each particular occasion was pleasant and profitable.

And then to Macon. Could a city entertain more royally? How they secured such a unanimous desire to do for their guests as was shown by all the leading citizens of Macon is a wonder most confounding. With the Chamber of Commerce, the city editors, the civic clubs, the several organizations of men and women all uniting in entertaining these 300 out-of-town ceramists in perfect team work there was no lull in their attention.

The banquet Thursday evening in the Macon Colliseum cannot be adequately described. The food was excellent and in plenty, but it is safe to say that not one of the guests can in retrospect recall much about the food or its service, but of the huge clusters and banks of flowers, the heartiness of the personal welcome, the music by the organist, the entertainment by the local artists, and the dance with a thirty-piece orchestra will long remain in their several details in the memory of those who attended. Thanks is due to the many Macon men and women who so ably assisted Newton Barnes, P. T. Anderson and Lincoln McConnell.

Wilkinson County will be remembered as much by the fleet of two hundred and fifty automobiles which met the ceramic special at McIntyre as by its clay resources. The securing of these machines from the residents of Wilkinson County speaks volumes for the unanimously enthusiastic sponsoring of the County entertainment and the personal influence of M. T. Nichols and W. J. Jenkins.

The clay mines and plants of McIntyre were inspected with a lasting impression, but it is not with these that this note deals. It is the large and smoothly-working entertainment organization and the personal attentions we are here stressing. C. E. Todd, L. E. Riddle and George E. Simcoe were liberal hosts at the Klondyke mines and at Edgar Bros. plant, as were the operators of the other mines and plants in McIntyre.

And then Gordon with the bountiful barbecue under the spacious stock shed of the Georgia White Brick Company the open house and entertainment for the men at the home of M. T. Nichols, and for the ladies at the home of Mrs. R. E. Evans made impressions which will never grow dim. Indeed, as incidents are recalled, these occasions at Gordon will be brought more clearly to their deserved appreciation. The humorous, wise and cordial words of welcome by George H. Carswell will re-impress themselves in the memories of those who heard this "David Harum" of Wilkinson County, ex-Lt. Governor of the State, Colonel in the recent war.

To Dr. W. F. Demuth, the president and general manager of the Georgia White Brick Company, to Ray T. Stull and others of this same Company, to F. H. Opper, and the many other clay plant operators of Wilkinson County, the delegates owe a great deal. These are our fellow ceramists. It would be expected that they would do all they could to make this Wilkinson County trip informing and pleasant. But to Dr. R. E. Evans, a physician, who worked for months in a leading capacity, and whose efforts during the week were unabated, to M. T. Nichols, the president of the Pyntree Paper Company, to W. J. Jenkins, president of the local Automobile Club and secretary of the Gordon Chamber of Commerce and to many others who were not financially interested in clays and not before this occasion had knowledge of ceramics, but who acted as hosts, the 300 visiting delegates owe a great deal. We can not in this note give adequately, an expression of the appreciation which was

repeatedly spoken by each of the guests, and certainly words fail when attempting to tell of the splendid welcome extended by the ladies of Wilkinson County. To Mrs. R. E. Evans and Mrs. M. T. Nichols, and to each of their assistants, the entire visiting delegation is grateful, for their effective and untiring reception and entertainment.

Now back to Macon where on Friday evening the delegates had choice, without cost, of attending any of the theatres.

The Motorcade fleet of 200 machines which sped the party out ten miles to Dry Branch and back to the several ceramic plants in Macon was another distinct surprise. And for true Southern hospitality and cooking, no event was more unique and charming than the Saturday morning breakfast, consisting of beaten biscuits, delicious chicken and famous Georgia peach butter, given at the Hotel Lanier.

And the reception and lunch at the Idle Hour Country Club as guests of the Macon Chamber of Commerce was held Saturday afternoon. Here P. T. Anderson, Newton Barnes, Lincoln McConnell and their host of fellow townsmen and a bevy of charming Macon dames gave the delegates a farewell party that very fittingly concluded the week of hard work, and exhilarating entertainment. The friends which were made during that week by the generous people of Atlanta, Macon, and Wilkinson County will multiply, for from Ottawa in the far northeast, from Seattle in the far northwest, from Los Angeles in the distant southwest, and from all states in the union came the delegates who, on returning home, will not cease telling of the wonderful week they had in Georgia.

An item of most lasting value alike to Georgians and ceramists generally is the part played by the Georgia School of Technology throughout the three years prior to and during the Meeting week. Dr. M. L. Brittain was always on hand with a humorous cheer and a wise counsel but his foresight and work culminating in this great conclave of ceramists began many months ago. Inspired by J. M. Mallory, he visionized the influence of a department of ceramics at his school. His influence was soon felt by B. Mifflin Hood and others with the result that a ceramic building was provided and equipped, and classes conducted. Thus is A. V. Henry, present director of the Georgia Tech Department of Ceramics, brought into the picture. This trio, Brittain, Hood, and Henry, were not only powerful team mates with the men in Atlanta, Macon, Wilkinson County, and of the Central of Georgia Railway in making this Meeting a success, but they will continue, with J. M. Mallory, as the inspiring, the fact-finding and the substance-supplying factor in the follow-up activities of the Georgians. Only as the facts and truths are demonstrated by this ceramic school at Georgia Technology will definite and profitable results be obtained from the really stupendous entertainment and exposition which the Georgians staged during the week of February 8.

This twenty-eighth Annual Meeting of the AMERICAN CERAMIC SOCIETY was the greatest in program value and in broadening of friendship.

THE CHARLES FERGUS BINNS MEDAL

The Alumni of the New York State School of Clay Working and Ceramics at Alfred University have established a medal to be awarded annually to the person who shall be found to have made the most important contribution to the advance of Ceramic Art during the previous year.

This medal is in commemoration of twenty-five years of service of Charles Fergus Binns, who was made director of the above-named school at its founding in 1900. The award is to be decided by a Board of Jurors, five in number, constituted as follows:

Charles F. Binns or a substitute incumbent to be appointed by the President of Alfred University.

One member to be appointed by the Trustees of the AMERICAN CERAMIC SOCIETY. (Paul E. Cox has been appointed to serve for the SOCIETY.)

One member to be appointed by the National Terra Cotta Society.

One member to be appointed by the United States Potters' Association.

One member to be appointed by the Ceramic Guild of Alfred.

A nomination for the award must cite evidence of accomplishment and be accompanied by specific statements of fact. The evidence may consist of the actual production of a work of ceramic art; the discovery of a process or material; the investigation of a work of other time; or some specific contribution which in the opinion of the jurors shall constitute a valid claim.

Nominations may be made at any time to the Board of Jurors in care of the School of Ceramics, Alfred, New York.

ROBERT W. GARDNER

Mr. Gardner, Representative of the New York Society of Craftsmen of New York City gave an address on "The Standardized Proportions of the Greek Vase and Greek Ornament and Their Method of Application," at a general session held Tuesday, Feb. 9, at the Annual Meeting of the SOCIETY, Atlanta, Ga. A review of Mr. Gardner's recent book may be found at the end of *Ceramic Abstracts* for this month.

R. W. GARDNER

NEW MEMBERS RECEIVED FROM JANUARY 15 TO FEBRUARY 15

PERSONAL

C. L. Abney, Ceramic Engineer, Columbus Brick & Tile Co., Columbus, Ga.

Lawrence L. Anthes, 64 Jefferson Ave., Toronto, Canada. Managing Director and Secy.-Treas., Anthes Foundry, Ltd.

Harry Bedson, Lawrence Road, R. F. D. 4, Trenton, N. J.

C. Lester Bensel, 222 E. State St., Trenton, N. J. Industrial Gas Engineer, Public Service Electric & Gas Co.

Reginald A. Beverley, 1214 Newport Ave., Chicago, Ill. Sales Representative, Carborundum Co.

Ragnar Blomquist, Gen. Mgr., Höganas Billesholms Aktieboiag, Höganasverken, Overingenyoren, Germany.

H. F. Bowen, Canon City, Colo. Vice President and Treas., Diamond Fire Brick Co.

James H. Carmichael, Hephzibah, Ga. Superintendent of mining, Albion Kaolin Co.

Milton W. Caton, 8061 Russell St., Detroit, Mich. Foreman, Champion Porcelain Co.

Frederick C. Davis, 515 Buena Vista Ave., San Francisco, Calif. Structural Engineer, Gladding-McBean & Co.

Russel G. Eshenaur, 1120 Exeter St., Reading, Pa. Superintendent, Glen Gery Shale Brick Co.

Marion L. Fosdick, Garioon Studios, Alfred, N. Y. Professor of ceramic art at N. Y. State School of Clay Working and Ceramics.

Volney Foster, 122 S. Michigan Ave., Chicago, Ill. President, United States Silica Co.

John H. Freeman, Greenwood, Miss. President, Mississippi Clay & Mfg. Co.

Gustav B. Frosterus, Boulevardsg. 30, Helsingfors, Finland. Director of Soil Institution of Finland.

R. C. Gangewere, 53 Hogshead Apt., Chattanooga, Tenn. Superintendent, Chattanooga River Brick Co.

Robert W. Green, 8525 Butler Ave., Detroit, Mich. Director of Purchases, Champion Porcelain Co.

Henry T. Hellmers, Box 423, Clarksburg, W. Va. Chemist, The Akro Agate Co.

Edward C. Henry, 127 Maple Terrace, Merchantville, N. J. Student.

Leonard H. Hepner, 164 College Ave., New Brunswick, N. J. Student.

H. E. Johnson, Laclede Christy Clay Products Co., St. Louis, Mo.

E. Malcolm Jones, Box 975, Laurel, Miss. Soil Scientist.

William H. Kemler, Box 214, Johnson City, Tenn. Chemical and Mining Engineer.

Edward M. Kenworthey, c/o Charles Warner Co., 10th and King Sts., Wilmington, Del. Special Representative, Engineering and Development Dept.

Emil Kieffer, Meiningen, Germany. Chemist, Forschungsgesellschaft verein Porcellanfabriken.

George B. Lamar, Hephzibah, Ga. Manager, Albion Kaolin Co.

Richard Leek, Ogden, Utah. Manager, Ashton Fire Brick & Tile Co.

Chi Sheng Liu, Gen. Mgr., National Pottery Co., 96 Szechuen, Shanghai, China.

Mary H. Norton Macdonald, 412 Jackson Highway, Florence, Ala. Private Pottery Studio.

Edward E. Marbaker, Mellon Institute, Pittsburgh, Pa. Senior Industrial Fellow.

Mineichi Masuda, Research Laboratory, Tokyo Electric Co., Kawasaki, Kanagawaken, Japan.

John White McBurney, U. S. Bureau of Standards, Washington, D. C. Research Associate, Common Brick Mfrs. Assn. of America.

Lincoln McConnell, Jr., Mgr., Chamber of Commerce, Macon, Ga.

Charles Murty, Superior Enamel Products Co., 10th & Mullanphy, St. Louis, Mo. Superintendent, Enamel Dept.

Charles F. Perrine, E. Front St., Red Bank, N. J. Student.

Louis L. Petty, McIntyre, Ga. Chemist, Edgar Bros. Co.

Albert H. Podwell, Potter, Champion Porcelain Co., Detroit, Mich.

Arthur Powell, 169 Brunswick Ave., Trenton, N. J. Superintendent, "Ironside" Pottery, Bordentown, N. J.

Jack Reekers, Jr., 708 Crescent Ave., Covington, Ky.

Clarence E. Richholt, Holgate, Ohio. Sales Engineer, The Fate-Root-Heath Co., Plymouth, Ohio.

Adelaide Alsop Robineau, 204 Robineau Road, Syracuse, N. Y. Instructor in art ceramics, Syracuse University.

Alfred J. Sandorff, 121 Hamilton St., New Brunswick, N. J. Student.

Henry R. Schneider, 1220 Lake Ave., Rochester, N. Y. Manager, Dominion Feldspar Corp.

Frederick D. Shaw, Walker & Pratt Mfg. Co., Watertown, Mass.

Arthur C. Shepard, Black Lick, Ohio. Plant Supt., Claycraft Mining & Brick Co.

Laurence T. Sherwood, c/o Penna. Wire Glass Co., Dunbar, Pa.

Horace M. Siner, Church & Tacony Sts., Philadelphia, Pa. President, H. M. & C. B. Siner, Inc.

Alfred W. Smith, Spruce Pine, N. Car. Manager, Norman G. Smith & Co., Inc.

Stanton G. Smith, Box 94, Auburn, Maine, Treasurer, Maine Feldspar Co.
Alfred E. Stacey, Jr., 750 Frelinghuysen Ave., Newark, N. J. Research Engineer, Carrier Engineering Corp.
Benjamin J. Tarbutton, Sandersville, Ga. General Mgr., Sandersville Railroad Co.
George L. Toepfer, Supt., Canadian Potteries, Ltd., St. Johns, Que., Canada.
James Tunstall, 237 Cuyler Ave., Trenton, N. J. Kiln Engineer.
George H. Tyler, Purchasing Agt., The Pfaudler Co., Elyria, Ohio.
Samuel Wallace, R. F. D. 4, Heflin, Ala.
Curtis R. Watters, 2497 Adams Ave., Columbus, Ohio. Student.
Frank West, Haslemen, Green Lane, Buxton, Derbyshire, England. Chairman and Managing Director of Derbyshire Silica Fire Brick Co.
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R. A. Horning	3		E. J. Vachuska	1	
R. D. Landrum		1	W. Harry Vaughan	1	
H. A. Plusch		1	Office	26	4
				62	8

NEWS FROM THE LOCAL SECTIONS

The Pittsburgh Section

On January 21 the Pittsburgh Section held a joint meeting with the Pittsburgh Section of the American Chemical Society at the U. S. Bureau of Mines, Pittsburgh.

The speaker of the evening was W. J. McCaughey of the Department of Mineralogy of Ohio State University. Dr. McCaughey's subject was "The Interpretation of Fundamental Problems in Ceramics by Physical-Chemical and Mineralogical Studies." He explained in detail how to interpret the isothermal diagrams of the system SiO_2-CaO-Al_2O_3 in terms of what minerals were present and their relative amounts. He presented this more or less difficult topic in a way that emphasized the practical side of this highly theoretical subject. Slides of several open hearth bottoms were shown and the various minerals present were pointed out.

The evening turned out to be equally profitable for both chemist and ceramist.

Hobart M. Kraner of the Westinghouse Research Department has been elected Vice Chairman of the Section, succeeding C. E. Nesbitt.

Chicago Local Section

A meeting of the Chicago Local Section of the AMERICAN CERAMIC SOCIETY was held at the Great Northern Hotel in Chicago, January 16. Luncheon was served at 1:00 P. M., after which, the following officers were elected for the coming year: Chairman, B. S. Radcliffe; Vice Chairman, Leo Thurliman; Secretary, Robert C. Boyd; Chairman of the Program Committee, F. A. Guignon; Chairman of the Membership Committee, Rowland Manley.

Pacific-Northwest Section

The members of the Pacific-Northwest Local Section held a joint meeting with the Pacific-Northwest Manufacturers' Association and the Pacific-Northwest Clayworkers' Association, January 29–30. Officers for the Pacific-Northwest Local Section were elected as follows: Chairman, Samuel Geijsbeek; Vice Chairman, A. Lee Bennett; Secretary, Hewitt Wilson; Treasurer, John B. Stirrat; Trustees: Terra cotta, Z. Vare; Refractories, E. F. Goodner; Brick and tile, C. A. Houlahan; Sewer pipe, W. E. Lemley.

The Pacific-Northwest Manufacturers' Association held a general meeting on the afternoon of January 29 and the following program was given: Summary of the Association work of the year 1925 by H. R. Kreitzer; financial reports; election of new directors and talks on Association work by W. J. Howard of Seattle and M. B. Reilly of Portland.

On Friday evening, the Terra Cotta Division held a meeting with A. Lee Bennett, Chairman, presiding. The following papers were presented: 1. "Troubles with rubbed joints of terra cotta," by Samuel Geijsbeek; 2. "Studies in matt glazes," by Hewitt Wilson; 3. "Overglaze colors for polychrome terra cotta," by A. Lee Bennett; 4. Discussion of terra cotta reports from the U. S. Bureau of Standards research work in coöperation with the National Terra Cotta Society.

Saturday morning auto trips to industrial plants were made. A general meeting of the Pacific-Northwest Clay Workers' Association was held Saturday afternoon with Hewitt Wilson, President, presiding. The following program was presented: Business session; reports and election of officers; 1. "Practical practice in connection with the manufacture of sewer pipe," by W. E. Lemley; 2. "Notes on sewer pipe manufacture," by Gerry Johnson; 3. "Costs," by H. O. Thompson, Secretary, Manufacturers' Club of South Seattle; 4. "A test drier of the humidity type," by H. O. Fearn; 5. "Spalling test of fireclay brick." (Continued). By H. R. Goodrich; 6. "Some combustion problems in firing kilns," by H. N. Baumann, Jr.; 7. "Laboratory apparatus for washing kaolin," by R. J. Clark.

OBITUARY

H. D. Lillibridge

H. D. Lillibridge, Vice President and General Manager of the American Encaustic Tiling Company died suddenly in Los Angeles, California, on February 17, 1926.

While his death was altogether unexpected, Mr. Lillibridge has suffered from occasional attacks of illness during the past few years.

Mr. Lillibridge was born in May, 1870, and was consequently only fifty-five yearsold, and while he has been the directing head for a number of years of one of the largest ceramic organizations in the world, he was really only at the threshold of his career and busily occupied at this time in connection with further developments in the ceramic industry.

Mr. Lillibridge has been associated with the American Encaustic Tiling Company for nearly thirty five years. Commencing as assistant to Mr. Stanberry, the General Superintendent, he acquired a comprehensive knowledge of modern plant practice and ceramic organization work. He succeeded Mr. Stanberry as Superintendent at the latter's death and following the death of Emil Kohler in 1924, he was elected Vice President and General Manager. During the period that Mr. Lillibridge has been active head of the organization, considerable artistic and scientific development work has been done. The large Zanesville plant has been improved and considerably increased in size. The Company acquired factories in New Jersey and California and also an Office Building in New York City.

H. D. LILLIBRIDGE

Mr. Lillibridge was unquestionably one of the outstanding figures in the ceramic industry. He was not merely interested in the financial and administrative affairs, but he had a thorough knowledge of the practical and technical side of the industry, together with a keen appreciation of the possibilities of artistic developments. Under his direction and general supervision, a wide variety of ceramic products have been successfully produced and manufactured in large scale production.

Besides the standardized floor and wall tile products, the American Encaustic Tiling Company are large producers of architectural faience. Other developments include high temperature procelain wares, such as soda fountain equipment, bath room fixtures and high class art wares.

Mr. Lillibridge's death is an irreparable loss to the organization and it will tax the energy and ability of his associates to continue a development program on which he has been engaged during the past ten years.

Aside from his great ability as a directing force, Mr. Lillibridge was one of the most highly respected and best loved men in the industry. He was not merely kindly and patient, but he possessed the very rare ability to encourage and build up the younger members of the organization.

Very few men in control of a large industrial activity have so ably earned the complete confidence and affection as that inspired by Mr. Lillibridge, even by those who were little in contact with him; but those who were closely associated with him, while realizing their great loss, are most grieved because they have lost a real friend, who possessed an abundance of sympathy and understanding for all classes of labor in his employ.

E. Bertram Pike

The funeral services of E. Bertram Pike, President of the Cortland Grinding Wheel Co., Chester, Mass. and President of the Pike Manufacturing Co., Pike, New Hampshire were held Friday, February 19. Mr. Pike had been affiliated with the SOCIETY through his Companies for several years.

John A. Caldwell

Word has been received of the death of John A. Caldwell, President of the Savage Mountain Fire Brick Co., Frostburg, Md. Mr. Caldwell had been a member of the SOCIETY for two years.

NOTES AND NEWS

Chicago District Enameler's Club

An organization of the Chicago District Enameler's Club was effected in Chicago on the evening of January 7, 1926. C. W. Parmelee, of the Ceramic Department at the University of Illinois, gave the address of the evening, his subject being "Research." The officers elected were B. F. Wagner, Coonley Mfg. Co., Chairman, and F. E. Hodek, Jr., General Porcelain Enamel and Manufacturing Co., Secretary and Treasurer. The second meeting of this Club was held in Chicago on February 23.

IOWA CLAY PRODUCTS ASSOCIATION MEETING

The Ceramic Engineering Department of Iowa State College, Ames, Iowa, entertained the twenty-five members of the Iowa Clay Products Association, January 26 and 27, 1926. W. T. Quale, Redfield, Iowa, President of the Association, presided at the meetings. Addresses were made by Dean Anson Marson, Engineering Division, Iowa State College; R. H. Holbrook, Engineering Extension Department; J. E. Evans of the Psychology Department ; L. D. Benedict of the Engineering Economics Department.

An open discussion on the operation of plants twelve months of the year was led by O. J. Whittemore of Sheffield, Iowa. A. H. Kimball, head of the Architectural Engineering Department, spoke on color in architecture.

The following officers were elected for 1926: S. J. Galvin, Sheffield Brick and Tile Co., President; T. Neiswanger, Oskaloosa Brick and Tile Co., Vice President; Grover Galvin, Rockford Brick and Tile Co., Secretary-Treasurer.

In connection with the convention, the Ceramic Engineering Department sponsored a short course on January 25 to 29. This was a short course mainly for superintendents and foremen of the different heavy products plants of the state and consisted of a program of topics in which the owners of the plants are not particularily interested, but which are of importance to the men in direct contact with the work carried on in the plant.

Lectures for this course were given by Dr. Verl Ruth of the hospital staff who talked on first aid: A. H. Kimball, "On Getting Along with the Architect"; Wm. Maitland, Mechanical Engineering Department, "Sending Work to the Machine Shop"; J.A. Wilkinson, Chemistry Department on "Fine Stuff in Clays"; and "The Relation of Colloids in Clay to Its Workability" with demonstration by J. H. Griffith and M. G. Spangler; J. E. Evans, "Methods of Getting Along with Men"; D. A. Moulton, Ceramic Engineering Department, "Discussion of Driers"; R. A. Norman, Mechanical Engineering Department, "Fans, Their Use and Regulation"; D. A. Moulton, "Simple Clay Tests and How They Applied to the Heavy Products Industry."

Motion picture films were shown on the manufacture of Lenox China and the manufacture of the Denison block by the Mason City Brick and Tile Co.

BUREAU OF STANDARDS

Studies Clays for Making Saggers

Hopes to Reduce Expenses in Ceramic Industries

The short life of clay saggers is costing the ceramic industry of the United States millions of dollars annually. To assist the industry in eliminating this unnecessary cost the Bureau of Standards of the Department of Commerce has undertaken a comprehensive study of typical clays used in the making of these saggers, or heat resistant boxes, which are used to protect pottery and similar delicate products from flames and other deleterious substances (such as ash, carbon and oxides of sulphur) present in kiln gases.

The first progress report of this study will be published in an early issue of the *Journal of the American Ceramic Society*. It includes: (*a*) a summary of results obtained from a series of physical tests of the clays in both the raw state and after having been fired to various temperatures, (*b*) chemical analyses, and (*c*) petrographic examinations. As a result of this work the clays have been classified into five groups well defined by characteristic properties in the fired state. The paper also contains an outline of a proposed intensive and fundamental study of a limited number of clays typical of each group.

The Ceramic Society of England

The members of the Ceramic Society of England will hold meetings on March 8 and April 12 respectively. At the former meeting the following papers will be given: "The Scientific Treatment of Boiler Feed Water Introducing the Colloidal Aspect" by W. B. Lewis and G. S. Irving and "Defects of Slip Banded Ware" by W. Emery. At the April 12 meeting Geoffrey Martic will present a paper on "Research on the Theory and Fine Grinding. Parts IV and V".

The Society of Glass Technology

The January Meeting of the Society of Glass Technology was held in Manchester on January 20 and 21. During the morning of January 21, members of the Society had the privilege of visiting the works of the Metropolitan-Vickers Electrical Co., Ltd., at Trafford Park, Manchester.

The first session was devoted to a general discussion on "Refractory Materials for Glass Making," introduced by E. A. Coad-Pryor with a paper entitled, "The Use of Refractories in the Glass Industry." Three other papers were presented: "Some Experiments upon the Development of Sillimanite Refractories for Glass" by W. Angus McIntyre, "The Manufacture of Some Experimental Tank Blocks and Their Behavior in Service," by W. Angus McIntyre, and "Note on a Design for a Glass Pot Board," by F. Winks.

At the second session the following papers were presented: "Some Tests on Bottle Glasses with the View to Prescribing Standards of Composition," by H. S. Blackmore, and "The Homogeneity of Glasses Melted in Pots under Manufacturing Conditions," by Edith M. Firth and W. E. S. Turner.

CALENDAR OF CONVENTIONS

American Assn. of Flint and Lime Glass Manufacturers	April, 1926	Wheeling, W. Va.
AMERICAN CERAMIC SOCIETY	Feb. 1927	Detroit, Mich.
Summer Meeting	July, 1926	Philadelphia, Pa.

American Chemical Society (Spring Meeting)	April 5–9, 1926	Tulsa, Okla.
Amer. Electrochemical Society	April 22–24, 1926	Chicago, Ill.
American Foundrymen's Assn.	Sept. 27, 1926	Detroit, Mich.
American Gas Association	Oct. 11–14, 1926	Atlantic City, N. J.
Amer. Institute of Chemical Engineers	June 21–23, 1926	Berlin, N. H.
American Mining Congress	December, 1926	Washington, D. C.
American Refractories Institute	April 13, 1926	Pittsburgh, Pa.
Amer. Soc. of Mechanical Engineers	Dec. 6–9, 1926	New York City
Amer. Soc. for Testing Materials	June 21–26, 1926	Atlantic City, N. J.
American Zinc Institute	April 27–28, 1926	St. Louis, Mo.
Assn. Chemical Equipment Mfrs.	May 10–15, 1926	Cleveland, Ohio
Assn. Iron and Steel Mfrs.	May 31-June 5, 1926	Chicago, Ill.
The Ceramic Society of England	March 8 and April 12, 1926	Stoke-on-Trent, Eng.
Chamber of Commerce of the U. S.	May 10–13, 1926	Washington, D. C.
Grinding Wheel Mfrs. Assn.	March 12, 1926	New York City
Illinois Clay Mfrs. Assn.	April 13, 1926	Urbana, Ill.
Manufacturing Chemists' Assn.	May or June, 1926	Near New York City
Mirror Manufacturers Assn.	April, 1926	Pittsburgh, Pa.
National Acad. of Sciences (Spring Meeting)	April 26–28, 1926	Washington, D. C.
Natl. Assn. of Mfrs. of Pressed and Blown Glassware	March 9, 1926	Pittsburgh, Pa.
Natl. Assn. Stove Mfrs.	May 12–13, 1926	New York City
Natl. Clay Products Industries Assn.	March 18, 1926	Chicago, Ill.
National Safety Council	October 4–9, 1926	Detroit, Mich.
Natural Gas Assn. of America	May 17–20, 1926	Tulsa, Okla.
New Jersey Clayworkers Assn.	June, 1926	Trenton, N. J.
Ohio Ceramic Industries Assn.	October, 1926	Columbus, O.
Stained Glass Assn. of America	May 12–14, 1926	Washington, D. C.

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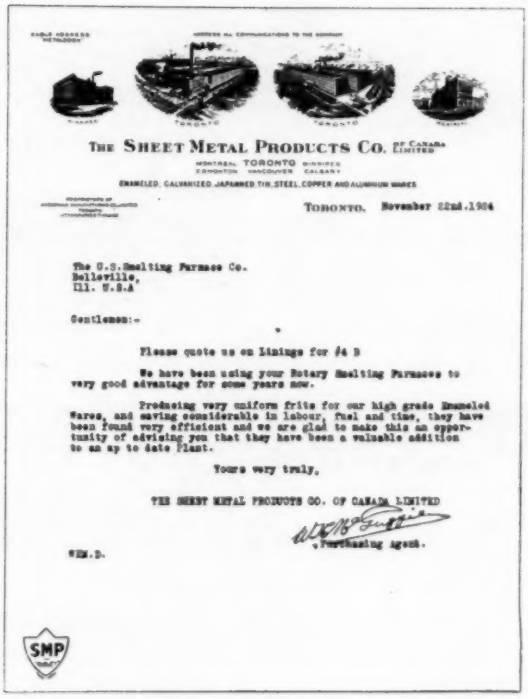

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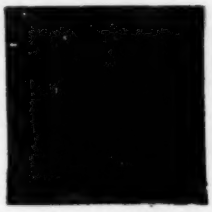

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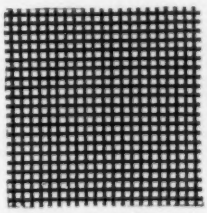

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Georgia Kaolin Refractory Brick

Write For These Bulletins

The utilization of Georgia Clays for refractories

Directory of Commercial Minerals in Georgia and Alabama along Central of Georgia Railway.

Washing Tests of Georgia Clays.

Georgia Clays for Paper Fillers.

Georgia Clays for Rubber Fillers.

Use of Sedimentary Kaolins of Georgia in Whitewares.

Kaolin and Refractory Clay Deposits in Wilkinson Co., Ga.

Utilization of Georgia Kaolins in the Manufacture of Face Brick

Distribution of Kaolin and Bauxite of the Coastal Plain of Georgia.

PRODUCTION loss and furnace rebuilding costs at one steel plant reach **$2,000,000** annually. It is estimated that better refractories here would save **$500,000.**

Thus far, tests of brick made from Georgia Kaolin have proved from 29 to 220% better than silica and special fireclay brick for use in electric steel furnaces and 266% better in open-hearth furnace ladles.

Abundant Raw Material Available

The supply of Kaolin in the Coastal Plain of Georgia along the Central of Georgia Railway is sufficient to meet the needs of the refractory industry for over 600 years. Deposits here cover an area of about 10,000 square miles.

Easy to Mine

Unlike fireclay deposits, Georgia Kaolin is found near the surface where it can be mined at low cost with steam shovels. Deposits run from 10 to 40 feet in thickness with little or moderate overburden. It is estimated that raw material in quantity can be mined at a cost of from 30 to 40 cents a ton as compared to an approximate cost of $1.50 to $2.00 a ton where underground mining is necessary.

Cheaper to Manufacture

Kaolin refractory brick is made of one clay, thus making it unnecessary to assemble two or more materials from widely separated sources—an economic advantage of great importance when considering the cost of production. Then too, power is reasonable and labor is plentiful.

Economical Shipping of Finished Brick

The average weight of standard sized kaolin brick is 6½ lbs. as compared to 7 lbs. average weight of standard sized fireclay brick. This alone means a saving of 500 lbs. per thousand brick—an item which reduces freight costs materially. Then too, freight rates are favorable and finished brick can be shipped either by rail or water to points of consumption. Freight service by rail is maintained to all points in the north and west through the principal gateways. Steamship service from Savannah to all important coast cities and foreign ports.

Real Opportunities Offered

The use of Georgia Kaolin for refractory brick is a comparatively new development. There is abundant opportunity to establish a large and prosperous industry here. Many desirable undeveloped properties are available. The Central of Georgia Railway has made a careful survey of deposits in this territory and is in position to furnish valuable suggestions to those interested.

Central of Georgia Railway

J. M. Mallory
Gen'l Industrial Agent

CENTRAL OF GEORGIA

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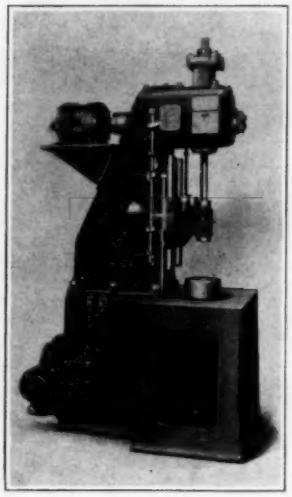

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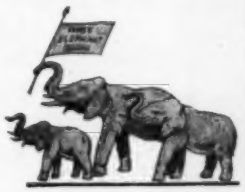

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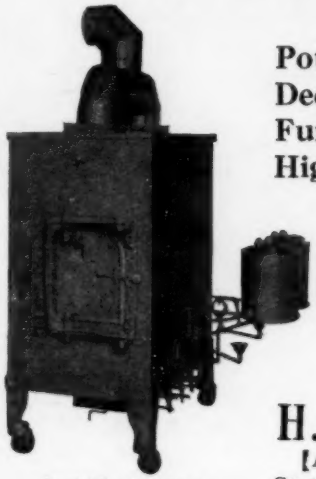

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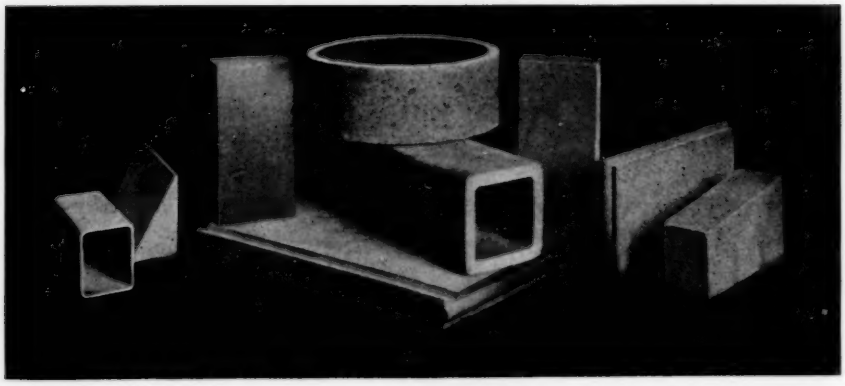
If fire-clay or other common refractory materials do not completely meet your needs let us prescribe Alundum (fused alumina), Crystolon (silicon carbide) or fused magnesia.

A few Norton refractory shapes are illustrated on this page.

NORTON CO., WORCESTER, MASS.



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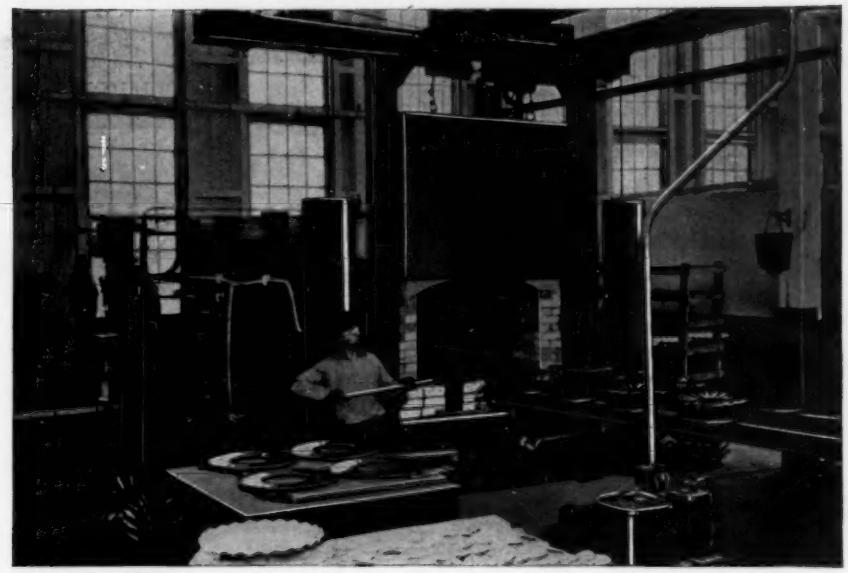

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Improving the product and reducing the cost of production are actual facts in the application of electric heat thru G-E Direct-Heat Units to vitreous enamel furnaces.

G-E Direct-Heat Units in your furnace mean no muffles to sag or break—no combustion gases and dirt—elimination of rejects due to spoilage by furnace—decreased labor for operating—and minimum upkeep on equipment.

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G-E Industrial Heating Specialists will gladly help you work out a better vitreous enamel furnace plan—through the proper application of electric heat.

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Competent men for responsible positions in the clay industries, available.

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Lord Hall, O. S. U.
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CERAMIC BREVITIES

The Foxboro Co., Inc., of Foxboro, Mass., makers of indicating, recording and controlling instruments, have announced the change of address of their Pittsburgh office. Formerly located in the Park Bldg., the Company has moved this office to what will now be known as the "Foxboro Building," on the corner of Sixth Avenue and Grant Street. The four upper floors of the building will be utilized for offices and the maintenance of a substantial stock of new instrument equipment, including Flow Meters, Indicating and Recording Gauges, and Thermometers, Controllers, etc.

The central location of this building should prove of exceptional advantage. Mr. H. S. Gray continues in charge of the Company's Pittsburgh branch.

The Carrier Engineering Corporation which has long specialized in the field of Air Conditioning Engineering has recently acquired all of the capital stock of the Atmospheric Conditioning Corporation of Philadelphia, Pa.

The entire Air Conditioning business of the latter company will be continued by the Carrier organization, while the Air Washer Business which the Atmospheric Conditioning Corporation formerly conducted has been recently purchased by Strandwitch & Scott, Inc., who will continue to manufacture and install Webster Air Washers with the Webster Dewpoint Control.

Mr. H. A. Terrell, Treasurer of the Atmospheric Conditioning Corporation, will have charge of a construction force for the consolidated Carrier Engineering Corporation and the Atmospheric Conditioning Corporation, and will be located at Newark, N. J.

Mr. E. Nesdahl, former Chief Engineer of the Atmospheric Conditioning Corporation will be connected with the Chicago Office of the two corporations.

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BUILDERS OF
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HIGH TEMPERATURE FURNACES
For all Purposes

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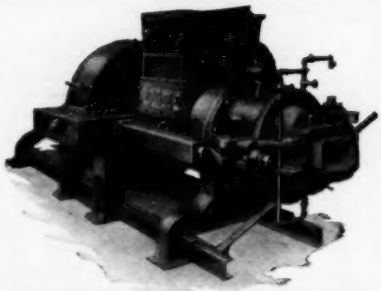

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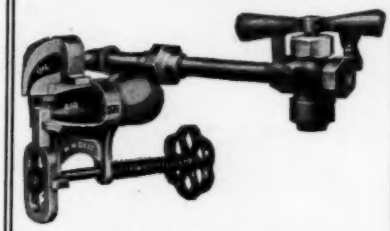

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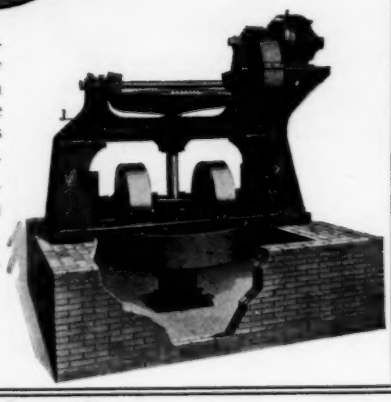

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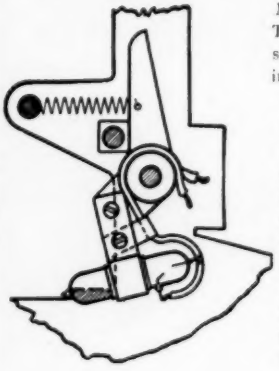
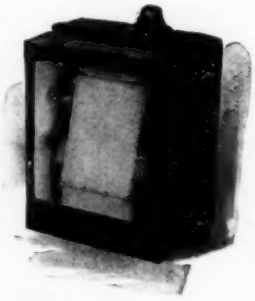


No more electrical contact troubles on pyrometer recorders. This sketch shows our new Mercury Contact Switch—the small glass bulb containing mercury. See the contact points inside the bulb at the right? See the mercury at the left?

When the bulb is tilted the other way the mercury envelopes the contact points and you have a flow of current. It is UNFAILING.

Ask for Bulletin No. 28 and learn about the OTHER many advantages of Engelhard Recorders.



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Inferior enameling metal is so much harder to handle in the shop that the labor cost is usually higher than if Toncan were used.

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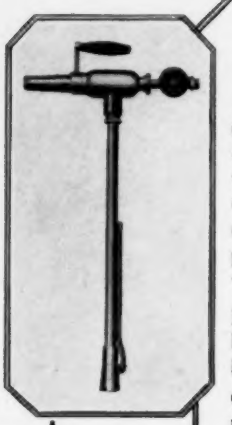

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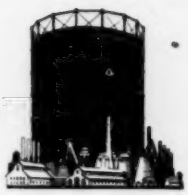

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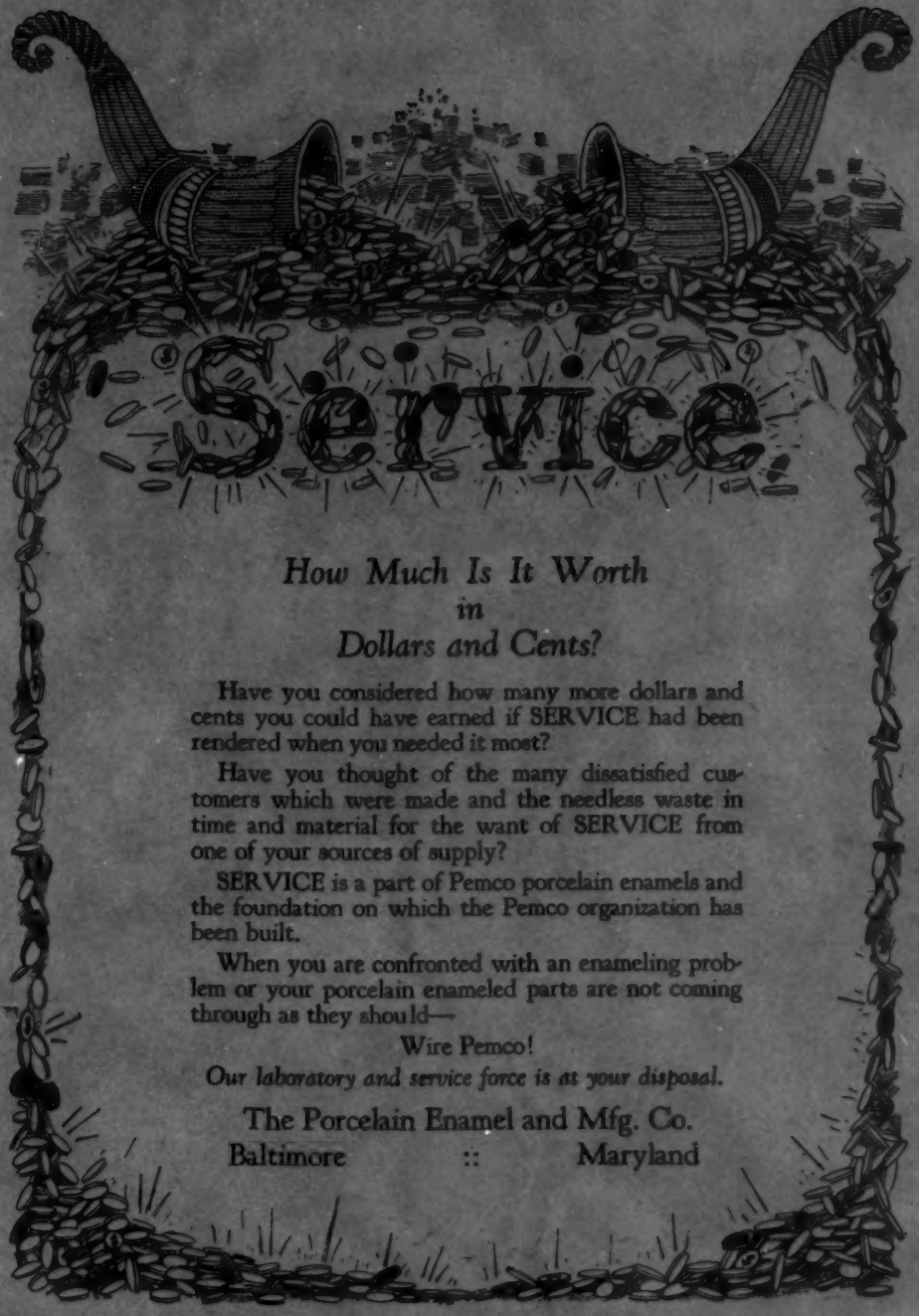

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